

## Blackmon, Amanda

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**From:** Jamie Ewing <Jamie.Ewing@lrwra.com>  
**Sent:** Monday, December 28, 2020 3:12 PM  
**To:** Carstens, Loretta  
**Cc:** John Holloway; Walter Collins  
**Subject:** FW: New Construction Permit application - submitted through ePortal

Loretta,

Thanks for your follow-up call. Yes, "for permit review purposes" does mean that we intend to proceed with construction according to these plans and specs, but as you recognize things may change and we will update you on any changes.

--Jamie

During this COVID-19 health crisis, LRWRA is continuing to provide customer service while implementing safety precautions to protect residents and employees. There may be a slight delay in email correspondence; but we will respond as soon as possible.

### Jamie Ewing

Director of Environmental Assessment  
11 Clearwater Dr.  
Little Rock, AR 72204  
Office: (501)688-1486  
[www.lrwra.com](http://www.lrwra.com)



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**Sent:** Monday, December 28, 2020 2:17 PM  
**To:** Carstens, Loretta <[loretta.carstens@adeq.state.ar.us](mailto:loretta.carstens@adeq.state.ar.us)>  
**Subject:** RE: New Construction Permit application - submitted through ePortal

Loretta,

I'm attaching the signed and stamped plans and specs to a series of emails. I'm not sure I could send all three in one email, so I'm separating them. If you have any trouble with the attachments, please let me know.

Thanks,  
Jamie

(Email 1 of 3) - Drawings

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**From:** Carstens, Loretta <[loretta.carstens@adeq.state.ar.us](mailto:loretta.carstens@adeq.state.ar.us)>  
**Sent:** Wednesday, December 23, 2020 8:42 AM  
**To:** Jamie Ewing <[Jamie.Ewing@lrwra.com](mailto:Jamie.Ewing@lrwra.com)>  
**Cc:** John Holloway <[John.Holloway@lrwra.com](mailto:John.Holloway@lrwra.com)>; Walter Collins <[Walter.Collins@lrwra.com](mailto:Walter.Collins@lrwra.com)>; Eric Wassell

<[Eric.Wassell@lrwra.com](mailto:Eric.Wassell@lrwra.com)>

**Subject:** RE: New Construction Permit application - submitted through ePortal

The plans and specifications need to be signed and stamped by the Professional Engineer registered in Arkansas. Also, they cannot be marked or named "preliminary." We need the final ones. Design calculations (or a reason for not having them) which have been signed and stamped by the P.E. must also be submitted. If the information is received by Monday, December 28, 2020, a formal incompleteness letter will not be sent.

If you have any questions, please contact me at [loretta.carstens@adeq.state.ar.us](mailto:loretta.carstens@adeq.state.ar.us)

Loretta Carstens, P.E.  
Engineer, NPDES Permits

---

**From:** Jamie Ewing [<mailto:Jamie.Ewing@lrwra.com>]

**Sent:** Monday, December 21, 2020 1:48 PM

**To:** Carstens, Loretta

**Cc:** John Holloway; Walter Collins; Eric Wassell

**Subject:** New Construction Permit application - submitted through ePortal

Loretta,

I just wanted to drop you a note and let you know that I am submitting another construction permit application today through ePortal. It's for repair and reconfiguration of an equalization basin at our Fourche Creek Water Reclamation Facility. The basin holds wastewater from a local industry that discharges to the plant under our Pretreatment Program. The basin was not originally constructed to hold this wastewater and needs to be rehabbed to continue operations and protect the plant.

I did encounter one glitch with the online form. We did not use an outside engineering firm for this project. However, I could not make that selection on the form and I had to include the name of a consulting engineer in order to get it to work. So, I put in John Holloway, our Director of Engineering, as the consulting engineer but, again, we did all of this work in-house.

As always, please call me with any questions you have about the permit application.

Merry Christmas! I hope you and David are doing well...and the furbabies, of course.

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**Attachments:** Drawings\_FCWRF Industrial EQ Basin.pdf

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PLANS FOR

# FOURCHE CREEK WATER RECLAMATION FACILITY

## INDUSTRIAL EQUALIZATION BASIN

## REHABILITATION

PREPARED FOR

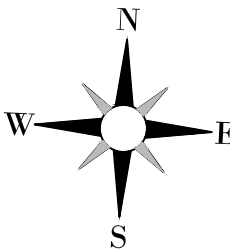
LITTLE ROCK WATER RECLAMATION AUTHORITY - PROJECT NO. 7190700

DECEMBER 2020



PREPARED BY

PROJECT ENGINEER: JOHN HOLLOWAY, P.E.



VICINITY MAP

N.T.S.

FOR PERMIT REVIEW ONLY

DRAWING INDEX

<u>SHEET NO.</u>	<u>SHEET TITLE</u>
1	SITE LAYOUT
2	OVERALL LAYOUT
3	PLAN VIEW
4	PLAN VIEW - PUMP VAULT
5	PLAN VIEW - PUMP DISCHARGE LINES
6	TYPICAL SECTIONS
7	TYPICAL DETAILS



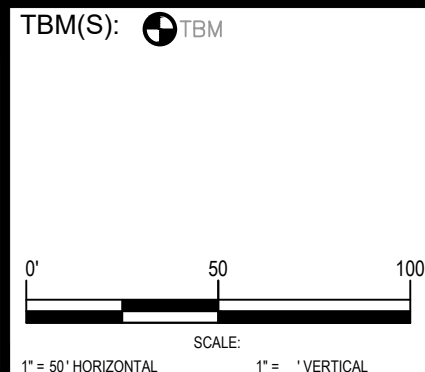


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1. FIELD VERIFY AND MARK LOCATIONS OF "ALL" EXISTING (E) UTILITIES AS WELL AS ELEVATIONS PRIOR TO ANY CONSTRUCTION.
2. EXISTING (E) SERVICE LINE LOCATIONS ARE APPROXIMATE. DETERMINATION SHALL BE MADE IN THE FIELD AS TO THE LOCATIONS AND WHETHER SERVICE IS "LIVE" OR "DEAD". REINSTATE "LIVE" SERVICES ONLY.
3. DATA CONTAINED IN THE PLAN VIEW PORTION OF THIS SHEET WAS COMPILED FROM VARIOUS SOURCES FOR THE SOLE USE AND BENEFIT OF THE PULASKI AREA. GEOGRAPHIC INFORMATION SYSTEM (PAIS) AND THE PUBLIC AGENCIES IT SERVES. IT IS A PERSPECTIVE REPRESENTATION BASED MAP ONLY. USE GIVEN DISTANCES ALONG WITH PROFILE INFORMATION. DO NOT SCALE PLAN VIEW.

LRW  
MAP BOOK  
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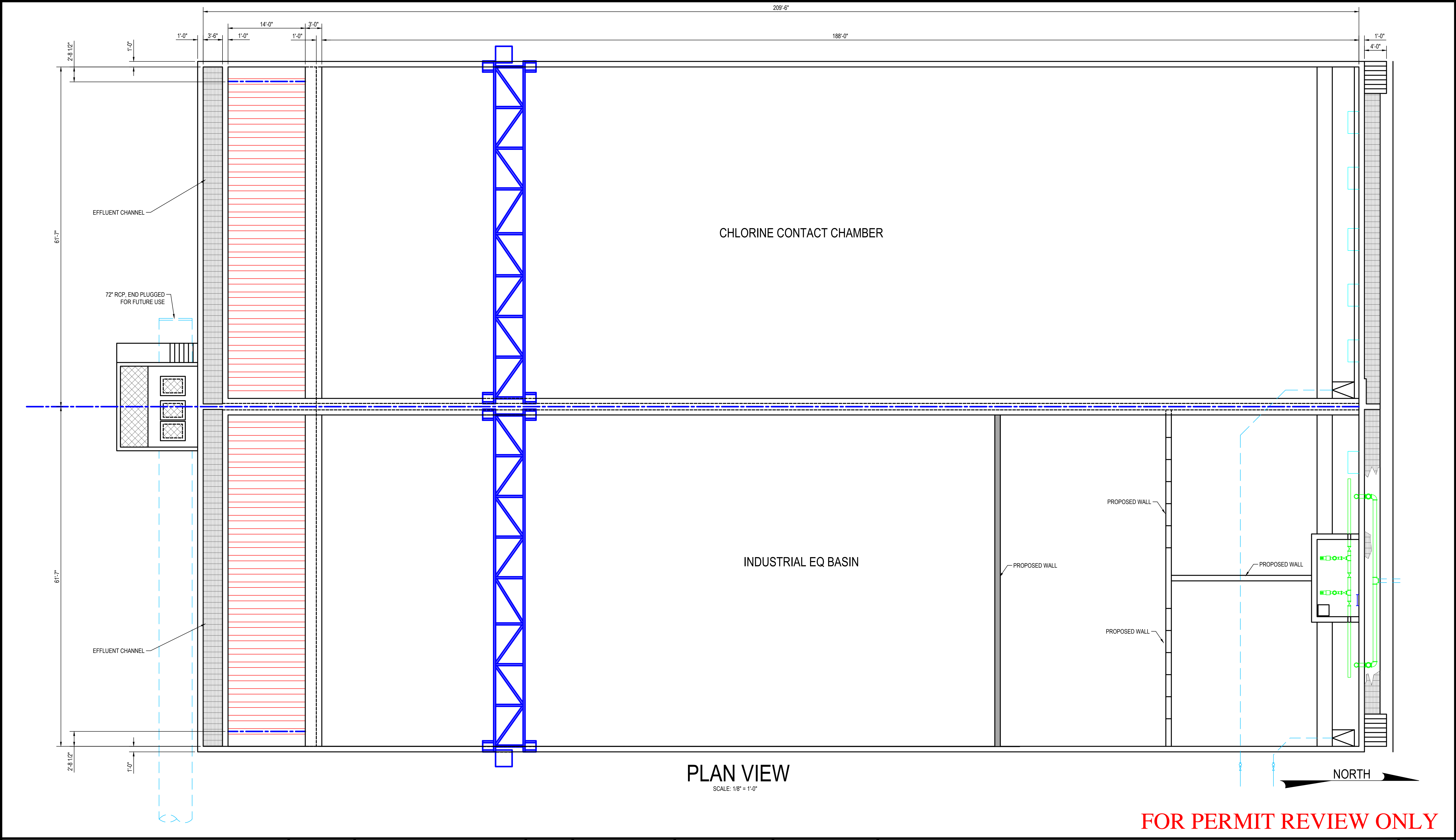


PROJECT #:	7190700
ENGINEER TECH:	S. Taylor
PROGRAM MANAGER:	C. Lipscomb
REVISED BY:	
DATE:	12/28/20
AS-BUILT DONE BY:	
DATE:	
CAD FILE:	002

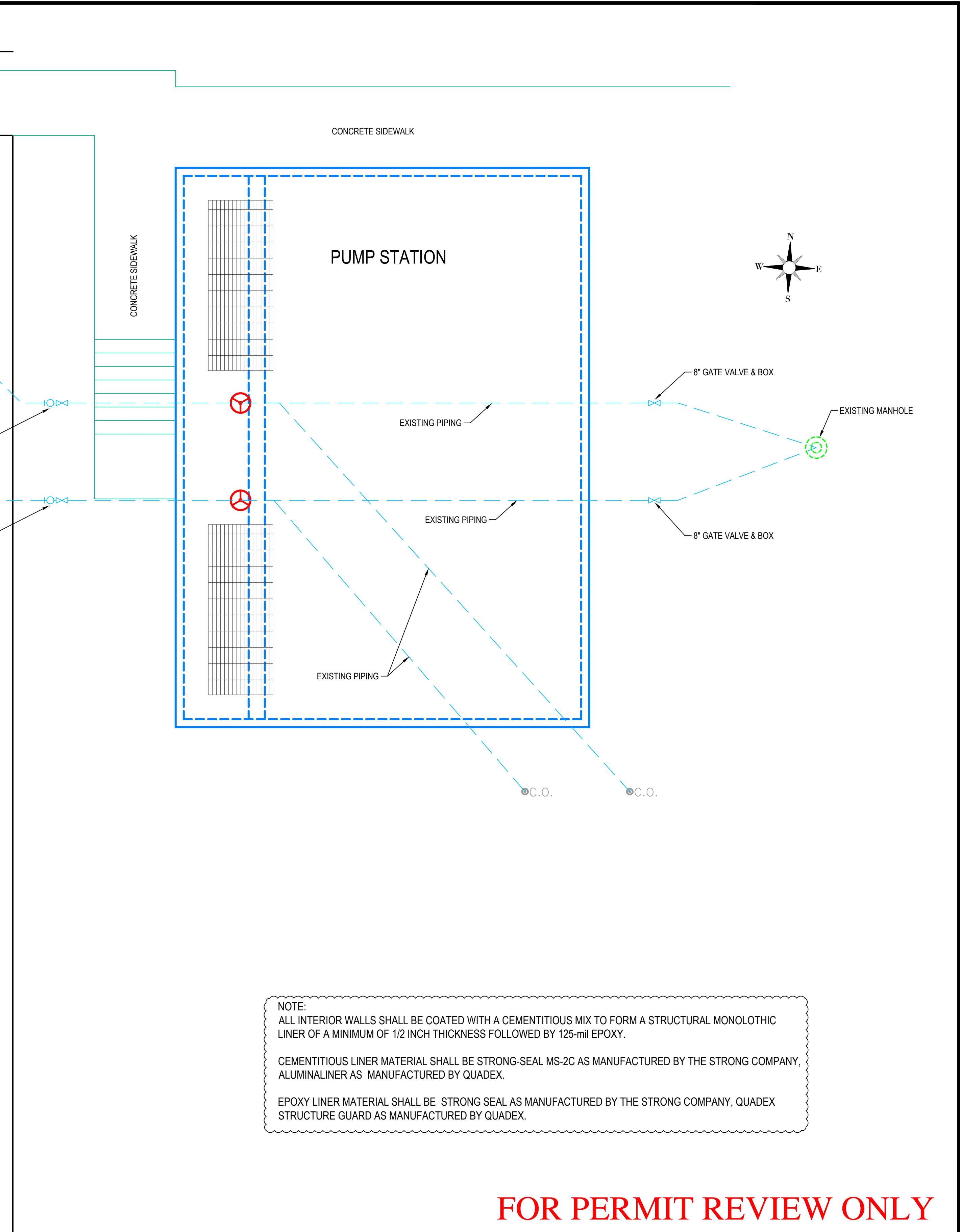
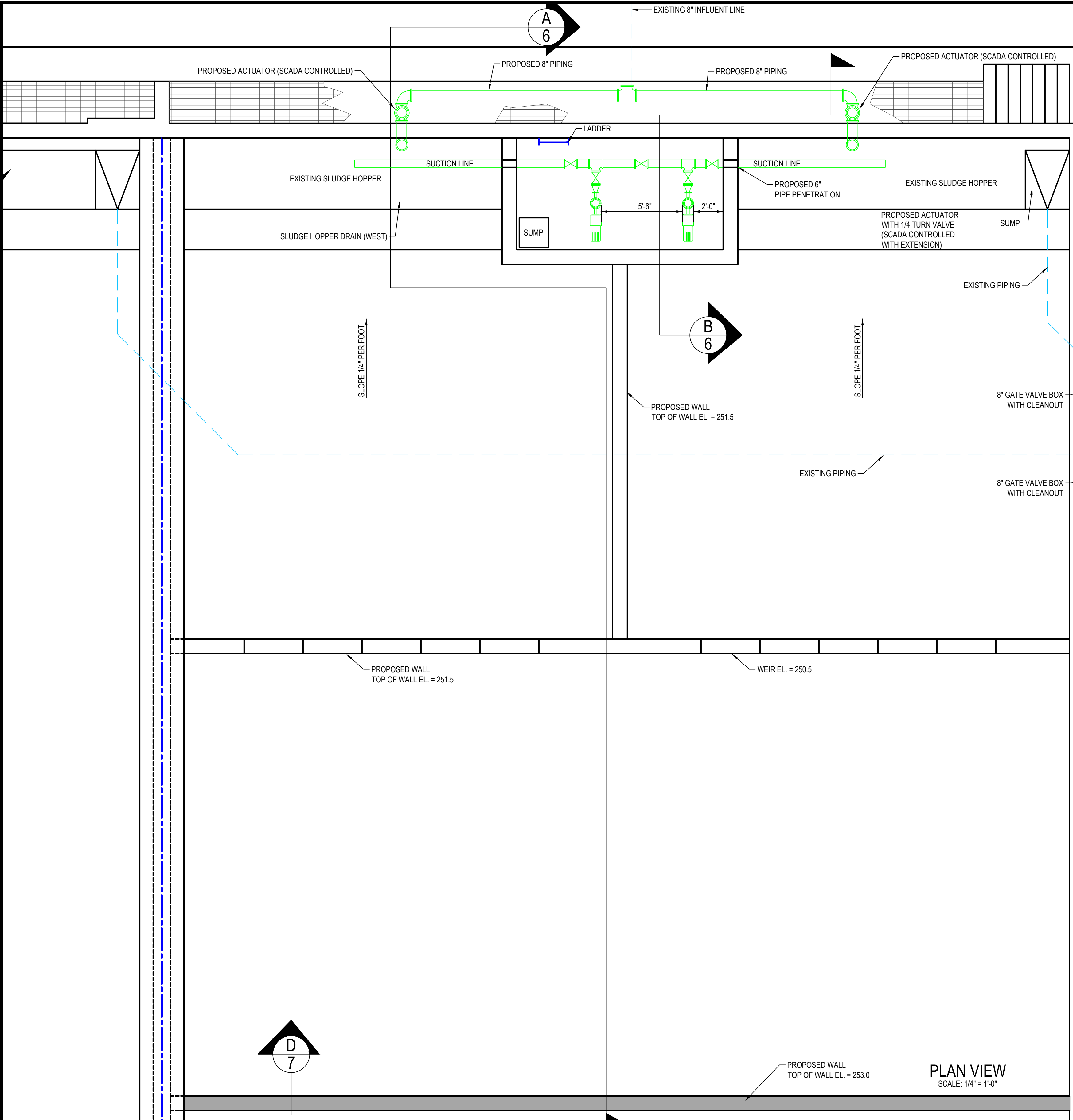


SITE LAYOUT  
FCWRF INDUSTRIAL EQ STORAGE TANK





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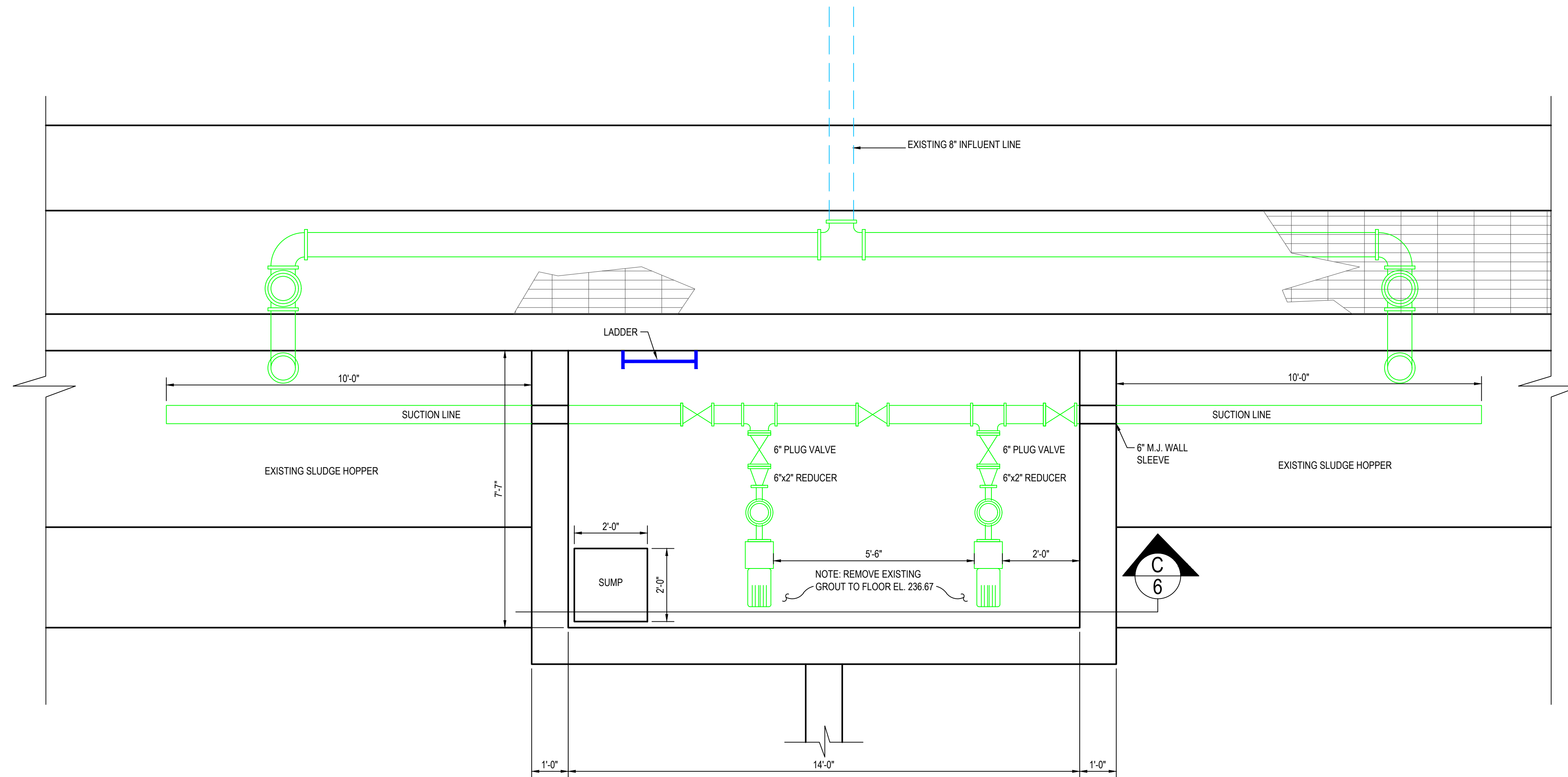


NOTE:  
ALL INTERIOR WALLS SHALL BE COATED WITH A CEMENTITIOUS MIX TO FORM A STRUCTURAL MONOLITHIC LINER OF A MINIMUM OF 1/2 INCH THICKNESS FOLLOWED BY 125-mil EPOXY.

CEMENTITIOUS LINER MATERIAL SHALL BE STRONG-SEAL MS-2C AS MANUFACTURED BY THE STRONG COMPANY, ALUMINALINER AS MANUFACTURED BY QUADEX.

EPOXY LINER MATERIAL SHALL BE STRONG SEAL AS MANUFACTURED BY THE STRONG COMPANY, QUADEX STRUCTURE GUARD AS MANUFACTURED BY QUADEX.

**FOR PERMIT REVIEW ONLY**



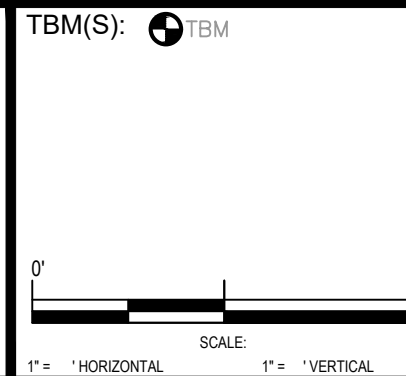
PLAN VIEW - PUMP VAULT  
SCALE: 1/2" = 1'-0"

FOR PERMIT REVIEW ONLY



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LRW  
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PAGE(S)  
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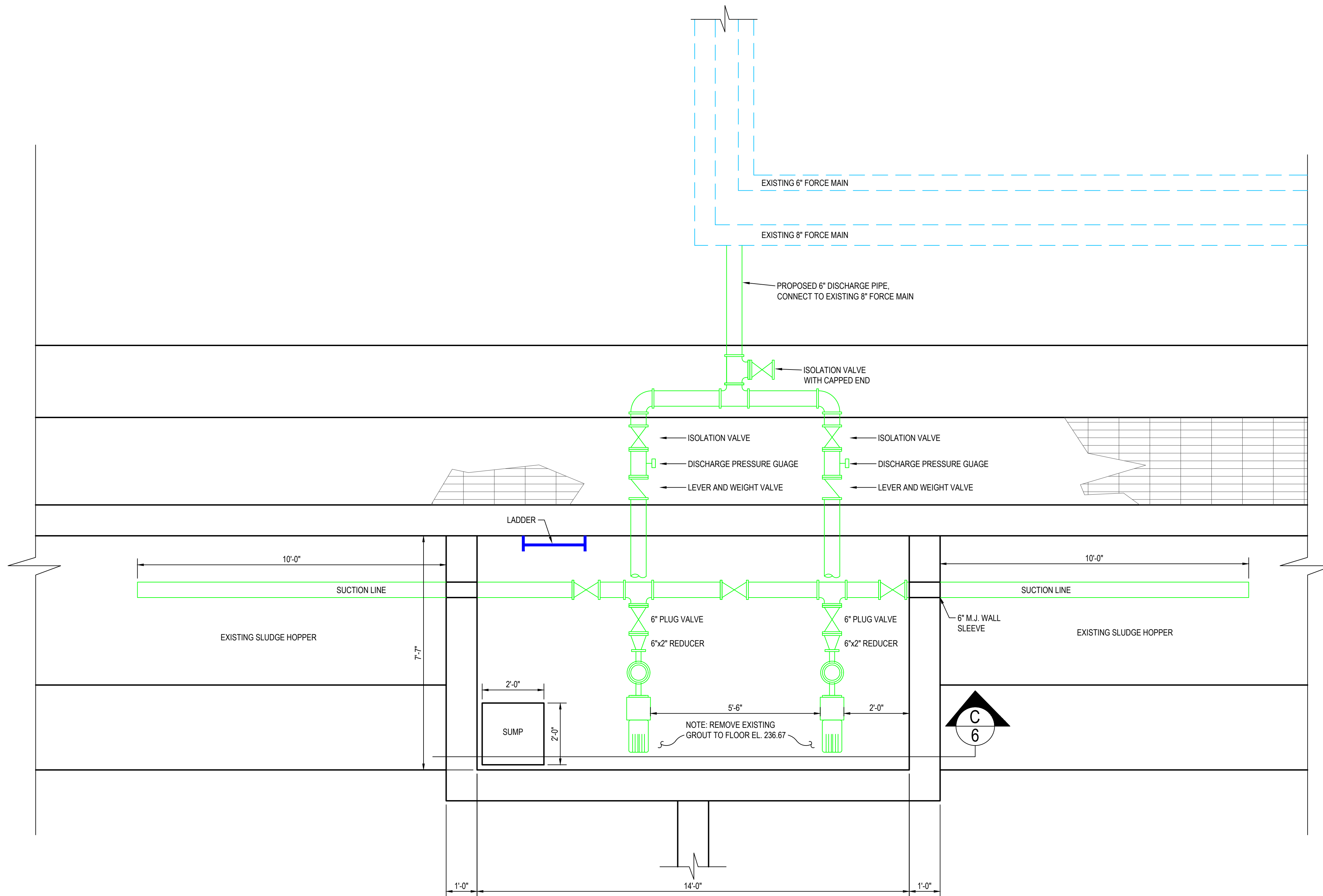
PROJECT #: 7190700  
ENGINEER TECH: S. Taylor  
PROGRAM MANAGER: J. Holloway  
REVISED BY:  
DATE: 12/23/20  
AS-BUILT DONE BY:  
DATE:  
CAD FILE: 004



PLAN VIEW - PUMP VAULT  
INDUSTRIAL EQ STORAGE BASIN REHABILITATION  
FOURCHE CREEK WATER RECLAMATAION FACILITY

SHEET  
NUMBER  
4  
OF





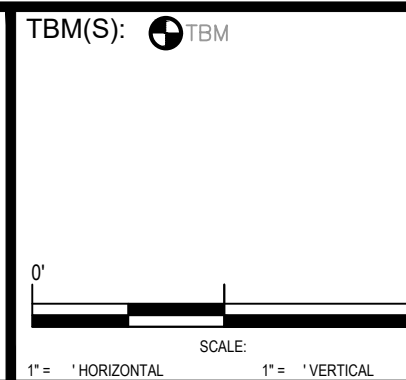
PLAN VIEW - PUMP DISCHARGE LINES  
SCALE: 1/2" = 1'-0"

FOR PERMIT REVIEW ONLY



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LRW  
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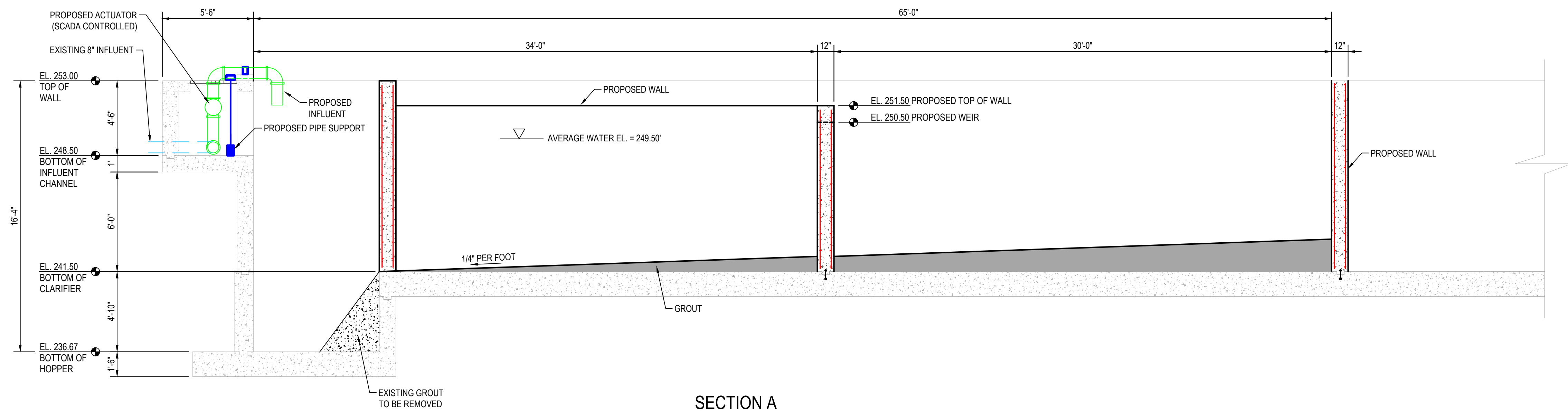
PROJECT #: 7190700  
ENGINEER TECH: S. Taylor  
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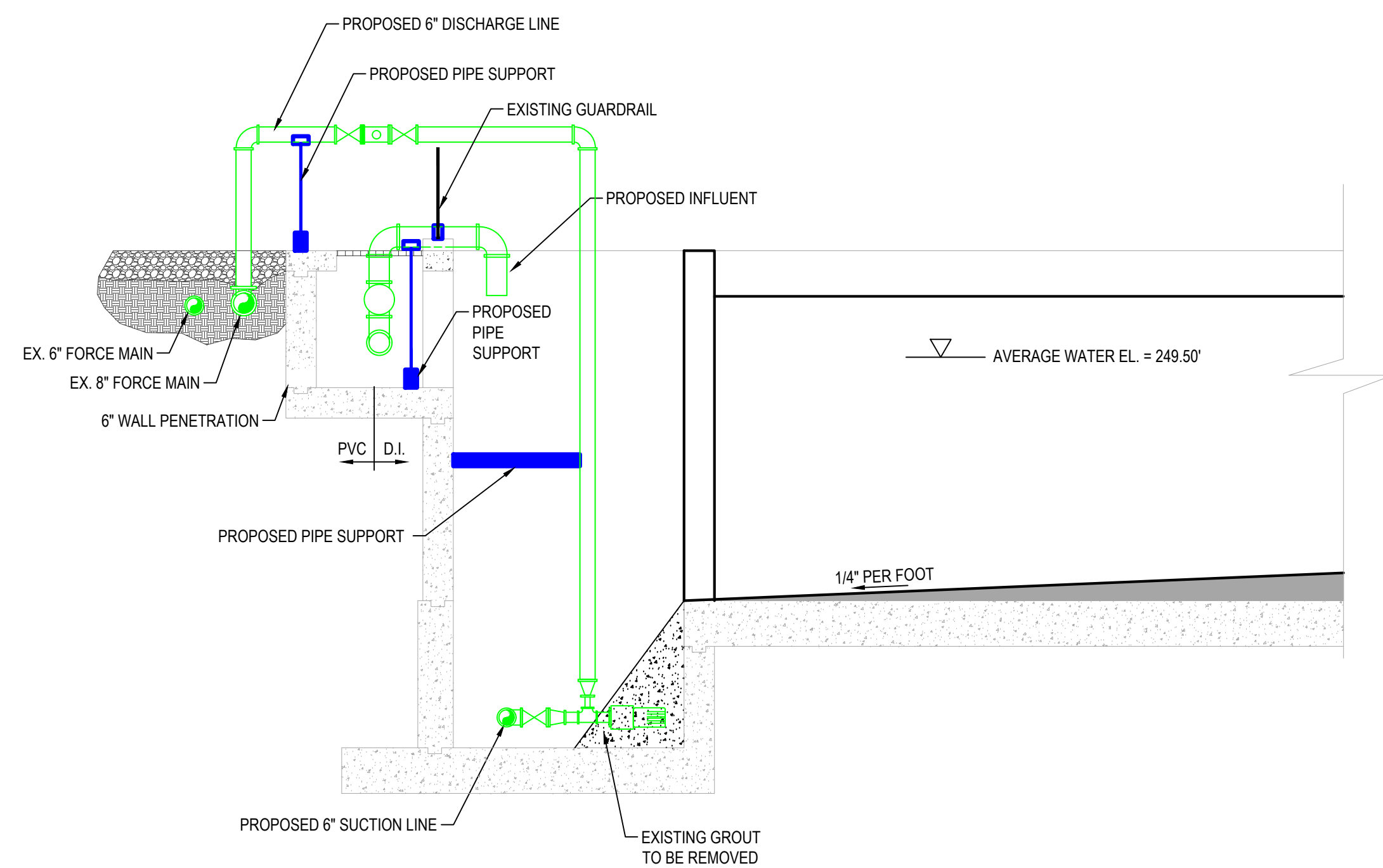
## PLAN VIEW - PUMP DISCHARGE LINES INDUSTRIAL EQ STORAGE BASIN REHABILITATION

FOURCHE CREEK WATER RECLAMATAION FACILITY

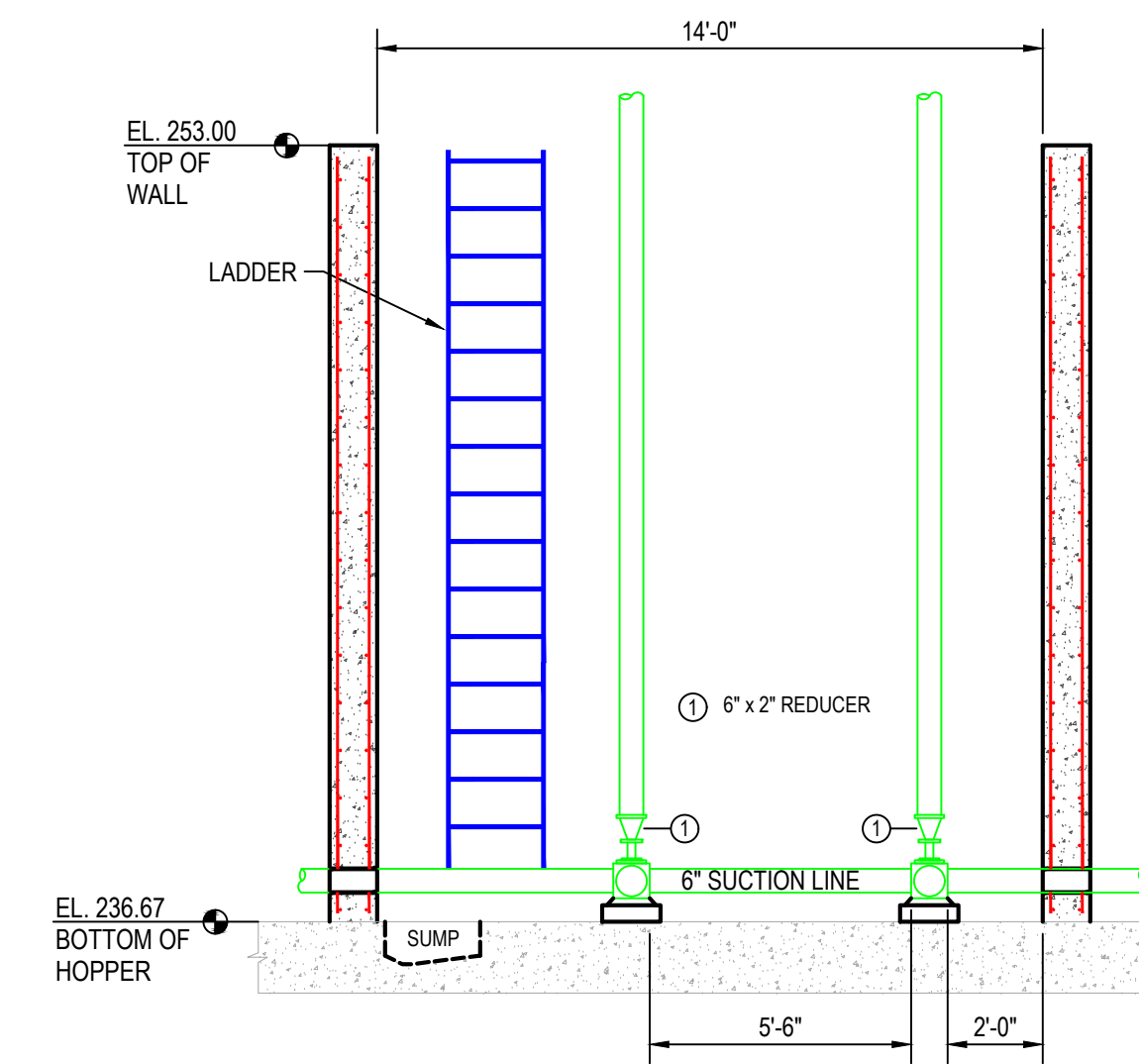
SHEET  
NUMBER  
**5**  
OF



SECTION A  
SCALE: 1/4" = 1'-0"



SECTION B  
SCALE: 1/4" = 1'-0"



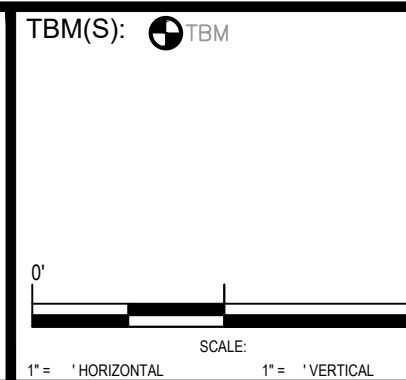
SECTION C  
SCALE: 1/4" = 1'-0"

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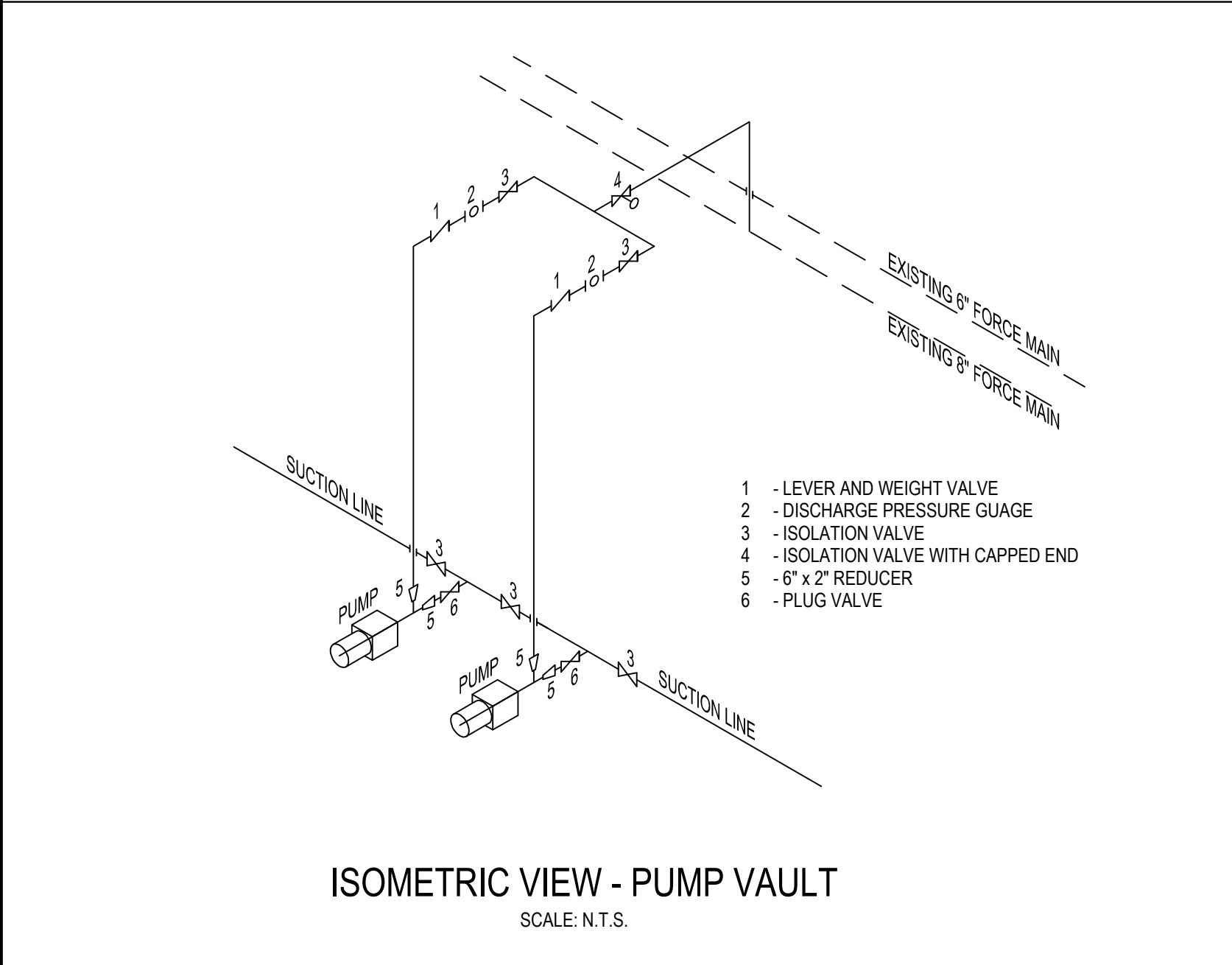
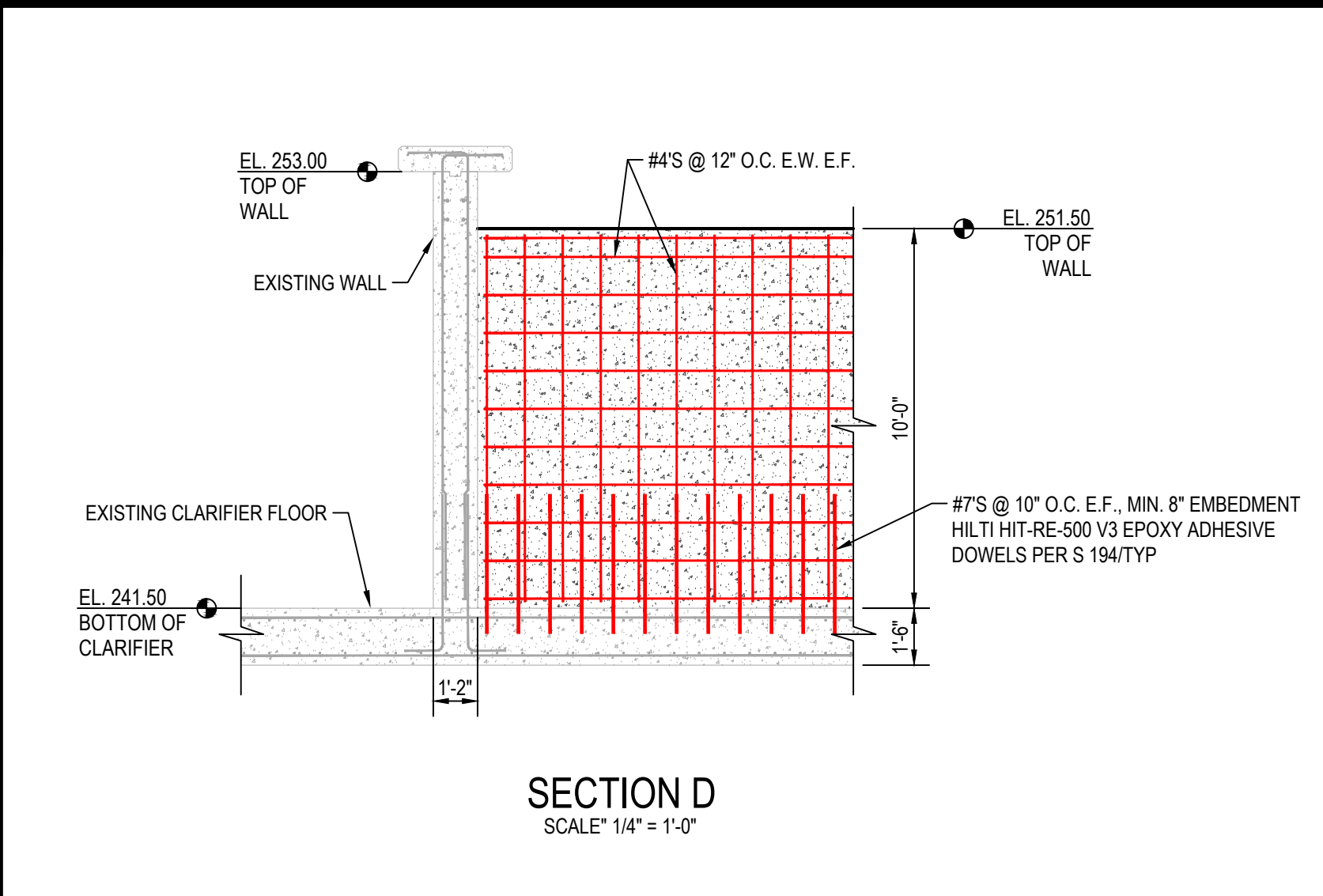


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TYPICAL SECTIONS  
INDUSTRIAL EQ STORAGE BASIN REHABILITATION  
FOURCHE CREEK WATER RECLAMATAION FACILITY

SHEET  
NUMBER  
6  
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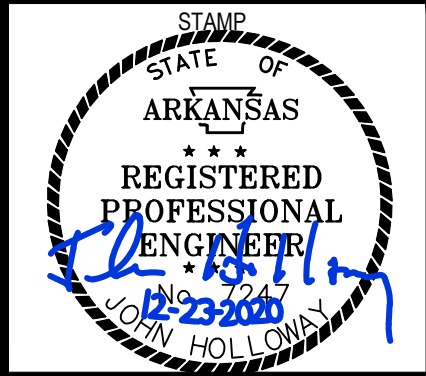
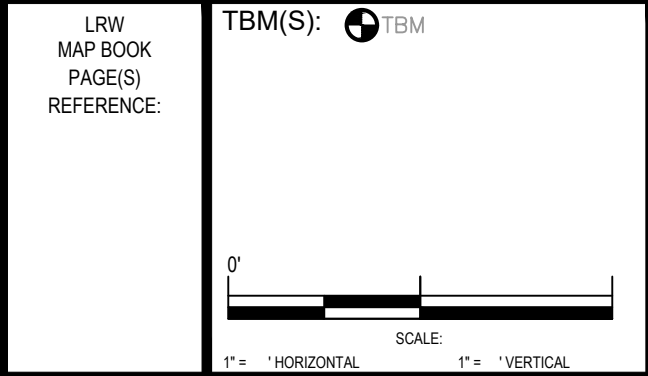
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TYPICAL DETAILS  
INDUSTRIAL EQ STORAGE BASIN REHABILITATION  
FOURCHE CREEK WATER RECLAMATAION FACILITY

SHEET  
NUMBER  
7  
OF



# **FOURCHE CREEK WATER RECLAMATION FACILITY: Industrial EQ Basin Modifications and Rehabilitation**

**Project # 7190700**

**Design Calculations**







## FOURCHE CREEK WATER RECLAMATION FACILITY:

### Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations

Prepared by: Cary B. Lipscomb, P.E. and Obatayo H. Hounwanou, P.E.

#### Basin Compartments Sizing

- \* Detention time = 6 hrs (per settlometer Analysis)
- \* Daily Weekly Avg Flow = 125,000 gallons
- \* Instantaneous Maximum Daily Flow = 180,000 gallons

$$\text{Detention Time (DT)} = \frac{V(\text{gal}) \times 24}{\text{Flow}(\text{gal/day})} \quad (1)$$

$$(1) \Rightarrow V(\text{gal}) = \frac{\text{DT}(\text{hrs}) \times Q(\text{gal/day})}{24}$$
$$= \frac{6 \times 180,000}{24}$$

$$= 45,000 \text{ gal} = 6,016 \text{ cf}$$

- \* Assuming side water depth of 8' and 30' wide,

$$L = \frac{6,016 \text{ cf}}{(8 \times 30) \text{ ft}^2}$$

$$L = 25.1 \text{ ft}$$

$V = 53,856 \text{ gallons for each EQ basin}$

Let's take  $L = 30 \text{ ft} \Rightarrow V = 8 \times 30 \times 30 = 7,200 \text{ cf}$



## FOURCHE CREEK WATER RECLAMATION FACILITY:

### Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations

Prepared by: Cary B. Lipscomb, P.E. and Obatayo H. Hounwanou, P.E.

## Head Calculations For Pump Selection

### \* Suction Lift

- Proposed drain pipe elevation = 235.52'
- Proposed centerline elevation for pumps = 245.17'
- Proposed 6" PVC pipe length estimate = 60'

$$\rightarrow \text{Static suction lift} = 245.17' - 235.52' = 9.65'$$

→ Fittings Equivalent lengths for 6" PVC pipe

	45° bend	90° bend	Tees	Plug Valves	
Eq. Length	7.1	15.3'	31'	3.2'	
#	0	6	4	2	
Total Eq. L	0	91.8'	124'	6.4'	222.2'

Therefore, total length of pipe  $L = 60' + 222.2 = 282.2'$

→ Friction losses per 100ft of pipe for 282.2' of 6" PVC @ 87 gpm (Cameron Hydraulic Data) is roughly 0.133 per  $f = 0.2083 \times \left(\frac{100}{C}\right)^{1.83} \times \frac{Q^{1.85}}{d^{4.3655}}$

Consequently, head loss  $h_f = 0.133 \times 2.822 = 0.375'$

## FOURCHE CREEK WATER RECLAMATION FACILITY:

### Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations

Prepared by: Cary B. Lipscomb, P.E. and Obatayo H. Hounwanou, P.E.

$$\rightarrow NPSH_a = h_a - h_{vpa} - h_{st} - h_f$$

$$= 34 - 0.7828 - 9.65 - 0.375$$

$$NPSH_a = 23.19 \text{ feet !!}$$

$h_a$  = head from atmospheric pressure

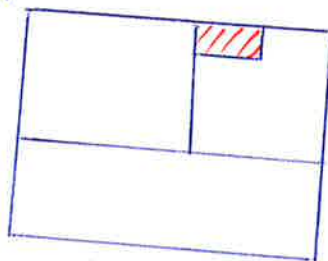
$h_{vpa}$  = vapor pressure of liquid

$h_{st}$  = static head (negative in case of lift)

$h_f$  = friction head

This value is high for a suction lift and will require specialized pumps, were the pumps installed in the old final sludge pump station.

- Reevaluation led to the proposal of a dry pump vault to be located in the proposed EQ basin compartment, offset to the east, as shown below:



Pump vault indicated by hatches in red.

This new configuration requires adjustment of the length of the two proposed EQ basins to maintain the necessary volumes of equalization.



## FOURCHE CREEK WATER RECLAMATION FACILITY:

### Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations

---

Prepared by: Cary B. Lipscomb, P.E. and Obatayo H. Hounwanou, P.E.

- Volume lost due to pump vault:

Vault dimensions : 7'-7" x 14' internally with 12" walls.

$$\text{Therefore } V = 8'-7" \times 15' \times 8' \times 7.48 = 7704.4 \text{ gallons.}$$

Previously calculated volume of EQ basins is

$$V = 53,856 \text{ gallons.}$$

Consequently, accounting for the pump vault volume, the new length  $L$  is

$$L = \frac{53,856 + 7,704.4}{(7.48 \times 8 \times 30)} = 34.29 \text{ ft.}$$

Let's take  $L = 34 \text{ ft.}$





## FOURCHE CREEK WATER RECLAMATION FACILITY:

### Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations

Prepared by: Cary B. Lipscomb, P.E. and Obatayo H. Hounwanou, P.E.

#### Total Dynamic Head Calculations

$TDH = \text{Elevation head} + \text{total friction losses}(f)$

- Elevation head = 40 ft.
- Total Friction losses determination (6" PVC pipe)

	45° bend	90° bend	Tee	Plug valves	Check valve	
Equivalent Length	7.1'	15.3'	31'	3.2'	39'	
Number	3	9	6	6	4	
Total Eq L.	21.3'	137.7	186'	19.2'	156'	520.2'

- Total length of pipe =  $750 + 520.2 = 1,270.2$  ft.

Per Cameron Hydraulic Data, friction losses per 100 ft of pipe for 6" PVC @ 87 gpm is roughly 0.133'.

$$\text{Consequently, } f = \frac{0.133 \times 1270.2}{100} = 1.69'$$

$$TDH = 40 \text{ ft} + 1.69 \text{ ft}$$

$$\underline{\underline{TDH = 41.69 \text{ ft} \approx 42 \text{ ft}}}$$



## FOURCHE CREEK WATER RECLAMATION FACILITY:

### Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations

Prepared by: Cary B. Lipscomb, P.E. and Obatayo H. Hounwanou, P.E.

New NPSHa based on current configuration.

- Proposed drain pipe elevation @ suction end = 238.00'
- Proposed centerline elevation for pumps = 237.42'
- Proposed 6" PVC drain pipe length = 10'

$$\rightarrow \text{Static suction head} = 238.00 - 237.42 \\ = 0.58'$$

$\rightarrow$  Fittings equivalent lengths for 6" PVC pipe

	45° bend	90° bend	Tee	Plug valves	
Eq. length	7.1'	15.3'	31'	3.2'	
#	0	0	1	3	
Total	0	0	31'	9.6'	40.6'

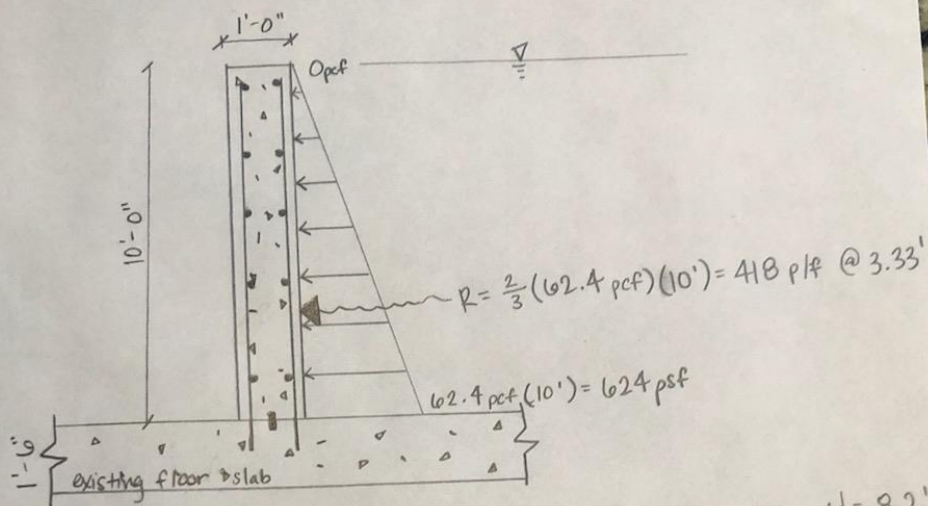
$$\therefore \text{Therefore, total length of pipe } L = 10' + 40.6' \\ \underline{\underline{L = 50.6'}}$$

$$\rightarrow \text{Consequently, } h_f = 0.067'$$

$$NPSH_a = 34 - 0.7828 + 0.58 - 0.067'$$

$$\underline{\underline{NPSH_a = 33.73'}}$$

# Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations



$$M = 418 \text{ plf} (3.33') = 1392 \text{ lb-ft/ft [water]}$$

$$= 16.7 \text{ K-in/ft}$$

$$f_y = 60,000 \text{ psi}$$

$$A_s = 0.44 \text{ in}^2$$

(#6 bars)

$$f_c = 4000 \text{ psi}$$

per S101-

cover over bars = 2"

$$\therefore d = 10" - \frac{0.75}{2} = 9.625"$$

$A_s \#6$

$$\phi M = 0.9 A_s f_y \left( d - \frac{a}{2} \right)$$

$$= 0.9 (0.44 \text{ in}^2) (60,000 \text{ psi}) (9.625")$$

$$= 194.4 \text{ K-in/ft [concrete wall]}$$

$$16.7 \text{ K-in/ft} < 194.4 \text{ K-in/ft}$$

$$\therefore \checkmark$$

$$d - \frac{a}{2} = 9.3" \quad jd = 8.2"$$

$$a = \frac{A_s f_y}{0.85 f_c b} = 0.65$$

try #4 bars

$$A_s = 0.2 \text{ in}^2$$

$$d = 10" - \frac{0.5}{2} = 9.75"$$

$$\phi M = 0.9 (0.2 \text{ in}^2) (60,000 \text{ psi}) (9.75")$$

$$= 89.5 \text{ K-in/ft [concrete wall]}$$

$$16.7 \text{ K-in/ft} < 89.5 \text{ K-in/ft}$$

$\therefore \checkmark$

assume #4 bars @ 12"

$$jd = 8.3" \quad d - \frac{a}{2} = 9.6"$$





# Industrial EQ Basin Modifications and Rehabilitation \_ Design Calculations



Deflection - fixed base, cantilever beam w/ concentrated load @ any point -

$$\Delta_{\max} = \frac{Ph^2}{6EI} (3l - b)$$

$$P = 418 \text{ lb}$$

$$h = 12''$$

$$l = 10' = 120''$$

$$b = 3.33' = 40 \text{ in}$$

$$E = \text{mod. of elasticity} = 3645 \text{ ksi (for } f'_c = 4000 \text{ psi)}$$

$$I = \text{mom. of inertia} = \frac{bh^3}{12} = 1728 \text{ in}^4$$

$$\Delta = 0.0056 \text{ in}$$



## **Specifications and Contract Documents**

# **Fourche Creek Water Reclamation Facility Industrial Equalization Basin Modifications and Rehabilitation**

## **Permit Review Set**





## DOCUMENT 00200

### INFORMATION FOR BIDDERS

#### 1. **DEFINED TERMS**

- 1.1 Terms used in these Information for Bidders which are defined in the Standard General Conditions and Supplemental General Conditions of the Construction Contract have the meanings assigned to them in the Supplemental and/or General Conditions. The term "Bidder" means one who submits a Bid directly to Owner, as distinct from Sub-Bidder, who submits a Bid to a Bidder. The term "Successful Bidder" means the lowest, qualified, responsible and responsive Bidder to whom Owner (on the basis of Owner's evaluation as hereinafter provided) makes an award. The term "Bidding Documents" includes the Advertisement or Invitation to Bid, Information for Bidders, the Bid Form, and the proposed Contract Documents (including all Addenda issued prior to receipt of Bids).
- 1.2 The term "Owner" means the Little Rock Water Reclamation Commission acting by and through Little Rock Water Reclamation Authority.

#### 2. **PROJECT FUNDING**

- 2.1 Project will be a combination of revenue funding and donated funds.

#### 3. **COPIES OF BIDDING DOCUMENTS**

- 3.1 Contract Documents for this Project have been made available to certain plan services. This distribution is made only as a convenience to potentially interested parties and is not intended as a mechanism for distributing bidding documents. Only hard copy versions of the Contract Documents, obtained directly from the Owner, will be accepted for bidding purposes.
- 3.2 Complete sets of Bidding Documents may be obtained from the Owner.
- 3.3 Complete sets of Bidding Documents shall be used in preparing Bids; the Owner does not assume any responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bidding Documents.
- 3.4 The Owner in making copies of Bidding Documents available on the above terms do so only for the purpose of obtaining Bids on the Work and do not confer a license or grant for any other use.



## **QUALIFICATIONS OF BIDDERS**

- 4.1 Each Bid must contain evidence of Bidder's qualifications to do business in the State of Arkansas or covenant to obtain such qualification prior to award of the Contract.

## **5. EXAMINATION OF CONTRACT DOCUMENTS AND SITE**

- 5.1 It is the responsibility of each Bidder before submitting a Bid, to (a) examine the Contract Documents thoroughly, (b) visit the site to become familiar with local conditions that may affect cost, progress, performance or furnishing of the Work, (c) consider Federal, State and Local Laws and Regulations that may affect cost, progress, performance or furnishing of the Work, (d) study and carefully correlate Bidder's observations with the Contract Documents, and (e) notify Owner of all conflicts, errors or discrepancies in the Contract Documents. The failure or omission of any Bidder to do any of the foregoing shall in no way relieve any Bidder from any obligation in respect to its Bid.
- 5.2 Bidders must satisfy themselves as to the estimated quantities in the Bid schedule by examination of the site and review of the Drawings and the Specifications, including Addenda. After Bids have been submitted, the Bidder shall not assert that there was a misunderstanding concerning the quantities of Work or of the nature of the Work to be done. Bidders shall acknowledge receipt of Addenda in the space provided on the Bid Form.
- 5.3 Information and data reflected in the Contract Documents with respect to Underground Facilities at or contiguous to the site is based upon information and data furnished to the Owner by owners of such Underground Facilities or others, and Owner does not assume responsibility for the accuracy or completeness thereof, unless it is expressly provided otherwise in the RLF Supplemental General Conditions.
- 5.4 Before submitting a Bid, each Bidder shall be responsible to make or obtain such explorations, tests and data concerning physical conditions (surface, subsurface and Underground Facilities) at or contiguous to the site or otherwise, which may affect cost, progress, performance or furnishing the Work in accordance with the time, price and other terms and conditions of the Contract Documents.
- 5.5 On request in advance, Owner will provide each Bidder access to the site to conduct such explorations and tests as each Bidder deems necessary for submission of a Bid. Bidder shall fill all holes, clean up and restore the site to its former condition upon completion of such explorations. A representative of the Owner shall be present during all tests.
- 5.6 Easement width for sanitary sewer lines and manholes is 5 feet either side of the pipe. All additional lands and access thereto required for temporary construction facilities or storage of materials and equipment are to be provided by Contractor. Easements for permanent structures or permanent changes in existing structures



are to be obtained and paid for by Owner.

## **6. INTERPRETATIONS AND ADDENDA**

- 6.1 All questions about the meaning or intent of the Contract Documents are to be directed in writing to the Owner. Interpretations or clarifications considered necessary by Owner in response to such questions will be issued by Addenda mailed or delivered to all parties recorded by Owner as having received the Bidding Documents. Questions received less than ten (10) days prior to the date for opening of Bids may not be answered. Only questions answered by formal, written Addenda will be binding. Oral and other interpretations or clarifications will be without legal effect.
- 6.2 Prior to the deadline for receiving Bids, Addenda may also be issued to modify the Bidding Documents as deemed advisable by Owner.
- 6.3 The Contract Documents contain the provisions required for the construction of the Project. Information obtained from an officer, agent, or employee of the Owner or any other person shall not affect the risks or obligations assumed by the Contractor or relieve the Contractor from fulfilling any of the conditions of the Contract.

## **7. BID SECURITY**

- 7.1 Each Bid must be accompanied by Bid security made payable to Owner in an amount of five (5) percent of the Bidder's maximum Bid price and in the form of a certified or bank check or a Bid Bond (on form attached), issued by a surety.
- 7.2 The Bid security of the Successful Bidder will be retained until Bidder has executed the Agreement and furnished the required Contract security, whereupon the Bid security will be returned. If the successful Bidder fails to execute and deliver the Agreement and furnish the required Contract security within ten (10) days after the Notice of Award, Owner may annul the Notice of Award, and the Bid security of that Bidder will be forfeited. The Bid security of other Bidders whom Owner believes to have a reasonable chance of receiving the award may be retained by Owner until the earlier of the seventh (7<sup>th</sup>) day after the Effective Date of the Agreement or the sixty-first (61<sup>st</sup>) day after the Bid opening, whereupon Bid security furnished by such Bidders will be returned upon request of the Bidder. Bid security with Bids which are not competitive will be returned within seven (7) days after the Bid opening upon request of the Bidder.

## **8. CONTRACT TIME**

- 8.1 The number of days within which the Work is to be substantially completed and also completed and ready for final payment (the Contract Time) are set forth in the Agreement and these Contract Documents.

## **9. LIQUIDATED DAMAGES**





Provisions for liquidated damages, if any, are set forth in the Agreement.

## **10. SUBSTITUTE OR "OR EQUAL" ITEMS**

- 10.1 The products specified herein are the standard of quality for use on this project. For products which are specified by naming one or more manufacturers preceded by "equal to" or followed by "or equal," equivalent products by other manufacturers are acceptable, providing they meet or exceed all performance criteria of the specified materials.

## **11. SUBCONTRACTORS, SUPPLIERS, AND OTHERS**

- 11.1 Subcontractors shall be listed in Section 00434. Suppliers shall be listed, if required, on the Bid Form.

## **12. BID FORM**

- 12.1 The Bid Form is included with the Bidding Documents.
- 12.2 All Bids must be made on the required Bid form. All blank spaces for Bid prices must be filled in, in ink or typewritten, and the Bid form must be fully completed and executed when submitted. Only one copy of the Bid form is to be submitted.
- 12.3 The Bidder shall submit a "Lump Sum" or "Unit Price Bid" for each item in the Bid Form. Unit price amounts shall be applied to the estimated quantities of work under each item to provide a total price for each item, and the aggregate amount for all items shall be the "Total Bid". The "Total Bid" shall be inclusive of the cost of all materials, equipment, labor, insurance, profit, taxes, and overhead.
- 12.4 Bids by corporations must be executed in the corporate name by the president or a vice president (or other corporate officer accompanied by evidence of authority to sign) and the corporate seal must be affixed and attested by the secretary or an assistant secretary. The corporate address and state of incorporation must be shown below the signature.
- 12.5 Bids by partnerships must be executed in the partnership name and signed by a partner, whose title must appear under the signature and the official address of the partnership must be shown below the signature.
- 12.6 All names must be typed or printed below the signature.
- 12.7 The Bid shall contain an acknowledgment of receipt of all Addenda (the numbers of which must be filled in on the Bid Form).
- 12.8 The address, telephone number, and fax number if applicable for communications regarding the Bid must be shown.
- 12.9 A conditional or qualified Bid will not be accepted.



### 13. **SUBMISSION OF BIDS**

- 13.1 Bids will be received by the **Little Rock Water Reclamation Commission acting by and through Little Rock Water Reclamation Authority** (herein called the "Owner"), at the time and place as designated in the **ADVERTISEMENT FOR BIDS**; and then at said time and place publicly opened and read aloud.
- 13.2 The Contractor shall submit the following documents with the Bid: Bid Form (Section 00410), Bidder's Statement of Subcontractors (Section 00434) and the Bid Bond (Section 00430).
- 13.3 Each emailed bid shall be a black and white scan of the physical bid documents, to include bid bonds or certified/bank check. The Authority would prefer one email of no more than 25 MB per bidder. The electronic bids are the official bid documents. The only purpose for sending the physical copies is the need for original security documents. Only bidders who have sent their bids electronically before 2:00 pm on **February 25, 2021** will be accepted. Mailed bids must be submitted in an opaque sealed envelope, addressed to Little Rock Water Reclamation Authority. Each sealed envelope containing a Bid must be plainly marked on the outside as **BID ENCLOSED – FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQUALIZATION BASIN**. The sealed envelope should bear on the outside the Bidder's name, Bidder's business address, Bidder's Arkansas contractor's license number, and the name of the project for which the Bid is submitted.
- 13.4 All sections of the Contract Documents and Specifications Manual shall be filled out entirely and all necessary signatures are required before Bid Proposal will be read aloud. If the Contract Documents and Specifications Manual is discovered to be incomplete or missing signatures, the bid will be returned to the Bidder and excluded from the Bid Opening.
- 13.5 If forwarded by mail or other delivery system, the sealed envelope containing the Bid shall be enclosed in a separate envelope with the notation "BID ENCLOSED", addressed and mailed to:

**Little Rock Water Reclamation Authority  
ATTN: Harold Hounwanou, P.E.  
11 Clearwater Drive  
Little Rock, AR 72204**

- 13.6 Attorneys-in-fact who sign Bid Bonds or Payment Bonds and Performance Bonds must file with each Bond a certified and effective dated copy of their Power of Attorney. Attorneys-in-Fact that sign Bonds must be licensed to conduct business in the State of Arkansas.
- 13.7 Any Bid received after the time and date specified shall not be considered.



## **14. MODIFICATION AND WITHDRAWAL OF BIDS**

- 14.1 Bids may be modified or withdrawn by an appropriate document duly executed (in the manner that a Bid must be executed) and delivered to the place where Bids are to be submitted at any time prior to the opening of Bids.
- 14.2 If within twenty-four (24) hours after Bids are opened, any Bidder files a duly-signed, written notice with the Owner and promptly thereafter demonstrates to the reasonable satisfaction of Owner that there was a material and substantial mistake in the preparation of its Bid, that Bidder may withdraw its Bid and the Bid security will be returned. Thereafter, that Bidder will be disqualified from further bidding on the Work to be provided under the Contract Documents.

## **15. OPENING OF BIDS**

- 15.1 Bids will be opened and (unless obviously non-responsible) read aloud on a Microsoft Teams call. An abstract of the amounts of the base Bids and major alternates (if any) will be made available to the Bidders after the opening of Bids. Bids will be returned without being read aloud if all applicable portions of the Contract Documents are not met by the Bidder.

## **16. BIDS TO REMAIN SUBJECT TO ACCEPTANCE**

- 16.1 All Bids will remain subject to acceptance for sixty (60) days after the day of the Bid opening, but Owner may, in its sole discretion, release any Bid and return the Bid security prior to that date.

## **17. AWARD OF CONTRACT**

- 17.1 Owner reserves the right to reject any and all Bids, to waive any and all informalities and to negotiate Contract terms with the Successful Bidder, and the right to disregard all nonconforming, nonresponsive, unbalanced or conditional Bids. Also, Owner reserves the right to reject the Bid of any Bidder if Owner believes that it would not be in the best interest of the Project to make an award to that Bidder, whether because the Bid is not responsive or the Bidder is unqualified or of doubtful financial ability or fails to meet any other pertinent standard or criteria established by Owner. Discrepancies in the multiplication of units of Work and unit prices will be resolved in favor of the unit prices. Discrepancies between the indicated sum of any column of figures and the correct sum thereof will be resolved in favor of the correct sum.
- 18.2 In evaluating Bids, Owner will consider the qualifications of the Bidders, whether or not the Bids comply with the prescribed requirements, and such alternates, unit prices and other data, as may be requested in the Bid Form or prior to the Notice of Award. Owner may accept any such alternatives in any order or combination, whether in the order in which they are listed in the Bid Form or not.



- 18.4 Owner may conduct such investigations as deemed necessary to assist in the evaluation of any Bid and to establish the responsibility, qualifications and financial ability of Bidders, proposed Subcontractors, Suppliers and other persons and organizations to perform and furnish the Work in accordance with the Contract Documents to Owner's satisfaction within the prescribed time.
- 18.5 If the Contract is to be awarded, it will be awarded to the lowest Bidder whose evaluation indicates to Owner that the award will be in the best interest of the Project.
- 18.6 If the Contract is to be awarded, Owner will give the successful Bidder a Notice of Award within sixty (60) days after the day of the Bid opening. Should there be reasons why the Contract cannot be awarded within the specified period, the time may be extended by mutual agreement between the Owner and the Bidder.

## **19. CONTRACT SECURITY**

- 19.1 The General Conditions and Supplemental General Conditions set forth Owner's requirements as to Performance Bond, Payment Bond and a Warranty Bond. When the successful Bidder delivers the executed Agreement to Owner, it must be accompanied by the required Performance and Payment Bonds. At the time of Final Acceptance, the Contractor shall provide the Owner the Warranty Bond.
- 19.2 A Performance Bond and a Payment Bond each in the amount of one hundred (100) percent of the Contract Price, with a corporate surety approved by the Owner, will be required for the faithful performance of the Contract.

## **20. SIGNING OF AGREEMENT**

- 20.1 When Owner gives a Notice of Award to the successful Bidder, it will be accompanied by the required number of unsigned counterparts of the Agreement and all other written Contract Documents attached. Within ten (10) days thereafter Contractor shall sign and deliver the required number of counterparts of the Agreement and attached documents to Owner with the required Bonds. Within ten (10) days thereafter, Owner shall deliver one fully-signed counterpart to Contractor. Each counterpart is to be accompanied by a complete set of the Drawings with appropriate identification.

## **21. PRE-BID CONFERENCE**

- 21.1 A **non-mandatory** prebid conference will be hosted virtually at 2:00 pm on **February 18, 2021**. Contractors need to be able to use Microsoft Teams. An invitation for the Microsoft Teams meeting will be sent to the bidder representative's email that requested the bid documents unless a different representative email address is provided. Please send the preferred email address for the prebid meeting by email to Harold.Hounwanou@lrwa.com no later than 4:30 pm Central Standard Time on **February 17, 2021**. Representatives of Owner will be present to discuss the Project. Bidders are reminded that any



representations or understandings arising from Prebid Conference shall not supersede the written provision of the Contract Documents themselves.

## **22. RETAINAGE**

- 22.1 Provisions concerning retainage are set forth in the RLF Supplemental General Conditions.

## **23. SPECIAL LEGAL REQUIREMENTS**

- 23.1 Attention of Bidders is called to Act 150, Acts of Arkansas 1965, concerning the licensing of contractors to do business in Arkansas.
- 23.2 It is conclusively presumed that Bidders have familiarized themselves with Arkansas laws which may be applied to a Contract for the Work proposed herein as the aforementioned Acts are not exclusive. It is further conclusively presumed that Bidders have familiarized themselves with Federal and local laws, ordinances and regulations pertaining to the Work proposed herein.
- 23.3 All applicable laws, ordinances and the rules and regulations of all authorities having jurisdiction over construction of the Project shall apply to the Contract throughout.
- 23.4 This Agreement shall be governed by the laws of the State of Arkansas and shall bind the Parties, their partners, heirs, successors, administrators and assigns.
- 23.5 Indemnification: The Contractor shall indemnify, defend, and hold harmless Owner, the agents, officers, employees, and representatives of Owner (hereinafter "Indemnified Parties") against all liability and loss including reasonable attorney's fees and expenses to the extent resulting from the negligence or willful misconduct in connection with the Project by the Contractor, any subcontractor, or the agents, employees, or representatives of the Contractor or any subcontractor, including any injury (including death) sustained by or damage to the property of any person; provided however, that the Contractor shall not be responsible for any injury (including death), damage, or loss (including reasonable attorney's fees and expenses) which is caused by the sole negligence of an Indemnified Party.
- 23.6 Remedies: Except as may be otherwise provided in the Agreement, all claims, counter-claims, disputes and other matters in question between Owner and the Contractor arising out of or relating to this Agreement or the breach thereof will be decided by arbitration if the parties mutually agree, or in Pulaski County Circuit Court, Arkansas. Each and every right and remedy of Owner and Contractor will be construed as cumulative and not exclusive of any right or remedy otherwise available at law or in equity.
- 23.7 Attorneys' Fees and Costs: If any action is filed for breach or enforcement of this Agreement, in addition to any damages to which the party may be entitled, the



prevailing party will be entitled to reasonable attorneys' fees and costs from the unsuccessful party.

- 23.8 Publicity: Contractor shall not issue a news release or article pertaining to this solicitation or any portion of the project, in any medium, at any time during the pendency of the solicitation or fulfillment of the terms of this Agreement without Owner's prior written approval. Contractor's failure to comply with this requirement may be cause for Owner's rejection of Contractor's Bid, or Owner's cancellation of this Agreement.
- 23.9 Confidentiality: Contractor and Owner shall be bound to confidentiality of any information that its employees may become aware of during the course of performance of contracted services. Consistent and/or uncorrected breaches of confidentiality may constitute grounds for cancellation of the Agreement.

## **28. CONE OF SILENCE**

- 28.1 All communication(s) pertaining to this solicitation shall be directed to **Cary Beth Lipscomb, P.E.**, or her designee. Little Rock Water Reclamation Authority has imposed an absolute prohibition against any communication or contact ("Cone of Silence") with any other Little Rock Water Reclamation Authority personnel, Little Rock Water Reclamation Authority consultant, or Little Rock Water Reclamation Commission member regarding this solicitation.
- 28.2 The prohibition begins with the publication of this solicitation document, remains in place through the Little Rock Water Reclamation Authority solicitation and award process, and ends only after Little Rock Water Reclamation Authority has executed a contract with the successful Bidder. The prohibition is suspended only when **Cary Beth Lipscomb, P.E.**, or her designee, initiates or consents to a meeting or communication to clarify the solicitation or for another solicitation-related purpose.
- 28.3 A violation of this policy may result in the disqualification of an offending Bidder's bid response.

## **29. DISCLOSURE OF BID INFORMATION**

- 29.1 The Owner will rely on a Freedom of Information Act (FOIA) exemption to withhold all information contained in any submitted bid document to the Owner until after Contract Execution. The Owner will also rely on an FOIA exemption to withhold the certified bid tabulation until after Contract Execution. After that time and pursuant to Arkansas statute, bid information will be available for public review upon FOIA request. All Bidders are hereby advised that any information that they may consider to be confidential or proprietary and would give a competitive advantage if disclosed, should be identified, along with a statement as to whether or not a claim of confidential or proprietary privilege is being asserted. If such information is later sought by a FOIA request, the Bidder will be allowed to justify its claim of privilege and the Owner will assess the validity of said claim in advance of any release.





**30. NOTIFICATION OF NONDISCRIMINATION**

- 30.1 All parties to this contract shall not discriminate on the basis of race, color, creed, sex, age, national origin, disability, marital status, sexual orientation, gender identity, genetic information, political opinions or affiliation, military status, or other status protected by applicable law.

**33. OSHA**

- 33.1 Successful bidder must comply with the requirements of Act 291 of 1993 concerning trenches or other excavations five (5) feet deep or more in accordance with OSHA standards.

**34. ENGINEER OF RECORD**

- 34.1 The Engineer for the Project is:

**Little Rock Water Reclamation Authority  
Attn: John Holloway, P.E.  
11 Clearwater Drive  
Little Rock, Arkansas 72204  
Telephone (501) 688-1416  
Fax (501) 688-1409**

**35. ISRAEL BOYCOTT NOTICE**

- 35.1 Pursuant to Arkansas Code Annotated 25-1-503, a public entity shall not enter into a contract valued at \$1,000 or greater with a company unless the contract includes a written certification that the person or company is not currently engaged in, and agrees for the duration of the contract not to engage in, a boycott of Israel.
- 35.2 Vendor's signature on the Bid Signature Page shall represent and warrant they do not boycott Israel and will not boycott Israel during the remaining aggregate term of the contract.







## SECTION 00410

### BID FORM

Date: \_\_\_\_\_

PROPOSAL of \_\_\_\_\_,  
(hereinafter called "Bidder"), organized and existing under the laws of the State of \_\_\_\_\_,  
Doing business as \* \_\_\_\_\_.

\*Insert "a Corporation", "a Partnership", or "an Individual", as applicable.

To the **LITTLE ROCK WATER RECLAMATION COMMISSION** by and through the **LITTLE ROCK WATER RECLAMATION AUTHORITY, LITTLE ROCK, ARKANSAS**,  
(hereinafter called "Owner"):

In compliance with your Advertisement for Bids, Bidder hereby proposes to perform all Work for the construction of **Fourche Creek Water Reclamation Facility Industrial Equalization Basin Rehabilitation** in strict accordance with the Contract Documents, within the time set forth therein, and at the prices stated below.

The Contractor's Act of Assurance Form must be included in the bid proposal. The DBE/MBE/WBE Compliance Evaluation Forms must be supplied after the Low Bidder is confirmed.

By submission of this Bid, each Bidder certifies, and in the case of a joint Bid, each party thereto certifies as to its own organization, that this Bid has been arrived at independently, without consultation, communication, or agreement as to any matter relating to this Bid with any other Bidder or with any competitor.

Bidder hereby agrees to commence Work under this Contract on or before a date to be specified in the Notice to Proceed and to fully complete the Project within 180 consecutive calendar days thereafter. Bidder further agrees to pay as liquidated damages, the sum of \$1,000.00 per day for each consecutive calendar day past Substantial Completion, then \$500.00 per day for each consecutive calendar day past Final Completion (30 days after Substantial Completion) thereafter as provided in the Supplemental General Conditions.

Bidder accepts all of the terms and conditions of the Information for Bidders, including without limitation those dealing with the disposition of Bid Security. This Bid will remain open for sixty (60) days after the day of Bid Opening. Bidder will sign the Agreement required by these Contract Documents within ten (10) days after the date of Owner's Notice of Award.



In submission of this Bid, Bidder represents, as more fully set forth in the Agreement, that Bidder has examined all Contract Documents (including but not limited to Advertisement, Information for Bidders) and the following ADDENDA: (Insert Number & Date of issue for each Addendum):

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Failure to list all necessary Addenda issued by the Owner or Engineer could mean the Bid submitted by the Bidder may be deemed unresponsive and not read publicly.

In submission of the Bid, Bidder represents, that they have examined the site and locality where the Work is to be performed, the legal requirements (Federal, State and Local Laws, Ordinances, Rules and Regulations) and the conditions affecting cost, progress or performance of the Work and has made such independent investigations as Bidder deems necessary.

In submission of the Bid, Bidder represents, that this Bid is genuine and not made in the interest of or on behalf of any undisclosed person, firm or corporation and is not submitted in conformity with any agreement or rules of any group, association, organization or corporation. The Bidder represents that they have not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid. The Bidder represents that they have not solicited or induced any person, firm or corporation to refrain from bidding and have not sought by collusion to obtain for themselves any advantage over any other Bidder or over the Owner.

All terms used in the Bid are defined and have the meanings assigned to them in the General Conditions and Supplemental General Conditions of these Contract Documents.

Attached to this Bid Form is the required Bid Security in the form of a Bid Bond or Certified Check in the amount of five (5) percent of the Total Bid Amount.

Bidder hereby agrees to perform all the Work described in the Specifications, called for in the Contract Documents, and shown on the Drawings for the following Prices:



**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQUALIZATION  
BASIN REHABILITATION AND MODIFICATIONS**

**BID FORM**

Item No.	Bid Item Description	Unit	Quantity	Item Unit Cost	Total Item Cost
(1)	FCWRF Industrial Equalization Basin Rehabilitation and Modifications	LS	1	\$	\$
(2)	Electrical improvements	LS	1	\$	\$
(3)	Mobilization (5%)	LS	1	\$	\$
<b>TOTAL BID:</b>	<b>\$</b>				

The above-stated Total Bid shall include all labor, materials, equipment, overhead, profit, insurance, taxes, and incidentals to cover the cost of the finished work of the various kinds called for to complete the Project in a manner in full accordance with the Specifications and Contract Documents; so as to be fully acceptable to the Owner.



Respectfully Submitted,

Bidder: \_\_\_\_\_

Signature: \_\_\_\_\_

Printed Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Telephone Number: \_\_\_\_\_

Fax Number: \_\_\_\_\_

Arkansas Contractor's License Number: \_\_\_\_\_

Seal (If Bidder is a Corporation)



## SECTION 00430

### BID BOND

KNOW ALL MEN BY THESE PRESENTS, that we, the undersigned,

\_\_\_\_\_,  
as Principal, and

\_\_\_\_\_  
as Surety, are hereby held

and firmly bound unto the **Little Rock Water Reclamation Commission** acting by and through the **Little Rock Water Reclamation Authority, Little Rock, Arkansas** as Owner in the penal sum of five (5) percent of the Principal's Total Bid for the payment of which, well and truly to be made, we hereby jointly and severally bind ourselves, successors and assigns.

Signed, this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.

The Condition of the above obligation is such that whereas the Principal has submitted to the **Little Rock Water Reclamation Commission** acting by and through the **Little Rock Water Reclamation Authority, Little Rock, Arkansas** a certain Bid, attached hereto and hereby made a part hereof to enter into a Contract in writing, for the construction of the:

### **FOURCHE CREEK WRF FOG RECEIVING STATION PROJECT**

NOW THEREFORE,

- (a) If said Bid shall be rejected, or
- (b) If said Bid shall be accepted and the Principal shall execute and deliver a contract in the Form of Contract attachment hereto (properly completed in accordance with said Bid) and shall furnish a Bond for faithful performance of said contract, and for the payment of all persons performing labor or furnishing materials in connection therewith, and shall in all other respects perform the agreement created by the acceptance of said Bid, then this obligation shall be void, otherwise the same shall remain in force and effect; it being expressly understood and agreed that the liability of the Surety for any and all claims hereunder shall, in no event, exceed the penal amount of this obligation as herein stated.

The Surety, for value received, hereby stipulates and agrees that the obligations of said Surety and its Bond shall be in no way impaired or affected by any extension of the time within which the Owner may accept such Bid; and said Surety does hereby waive notice of any such extension.



IN WITNESS WHEREOF, the Principal and the Surety have hereunto set their hands and seals, and such of them as are corporations have caused their corporate seals to be hereto affixed and these presents to be signed by their proper officers, the day and year first set forth above.

Signed this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_.

Principal:

\_\_\_\_\_

Signature: \_\_\_\_\_

Printed Name & Title:

\_\_\_\_\_

Surety\*:

\_\_\_\_\_

Signature: \_\_\_\_\_

Printed Name & Title:

\_\_\_\_\_

\*Surety must attach valid Power-of-Attorney

Important - Surety companies executing Bonds must appear on the Treasury Department's most current list (Circular 570 as amended) to transact business in the State of Arkansas.





SECTION 00434

STATEMENT OF BIDDER'S SUBCONTRACTORS

The undersigned **BIDDER** proposes and agrees, if this **BID** is accepted, to use the following proposed subcontractors on this **Work**:

NAME	BUSINESS ADDRESS	WORK TO BE PERFORMED
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
6. _____	_____	_____

Date: \_\_\_\_\_

Signed: \_\_\_\_\_

END OF SECTION







DOCUMENT 00510

NOTICE OF AWARD

Date: \_\_\_\_\_

To: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Project Description: **Fourche Creek WRF Industrial EQ Basin Rehab**  
**Little Rock Water Reclamation Authority**  
**Little Rock, Arkansas**  
**Owner's Project Number: 7190700**

You are notified that your Bid dated \_\_\_\_\_, for the above Project has been accepted. You are the apparent successful Bidder and have been awarded a contract for Fourche Creek Water Reclamation Facility Industrial EQ Basin Rehab.

The Contract Price of your Contract is \_\_\_\_\_  
\_\_\_\_\_

Three (3) copies of the proposed Contract Documents (except Drawings) accompany this Notice of Award. Three (3) sets of the Drawings will be delivered separately or otherwise made available to you immediately.

You must comply with the following conditions precedent within ten (10) days of the date of this Notice of Award, that is by \_\_\_\_\_, 2021.

1. You must deliver to the Owner five (5) fully-executed counterparts of the Agreement.
2. You must deliver with the executed Agreement five (5) fully-executed copies of Performance and Payment Bonds.
3. You must deliver with the executed Agreement five (5) fully-executed copies of Certificate of Liability Insurance listing, LRWRA, Engineer, and ANRC as additional insured.

Failure to comply with these conditions within the time specified will entitle Owner to consider your Bid abandoned, to annul this Notice of Award and to declare your Bid Security forfeited.

Within ten (10) days after you comply with those conditions, Owner will return to you one fully-signed counterpart of the Agreement with the Contract Documents attached.



Dated this \_\_\_\_\_ day of \_\_\_\_\_, 2021.

Owner:

Little Rock Water Reclamation Commission

By and Through Little Rock Water Reclamation Authority

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_ John Holloway \_\_\_\_\_

Title: \_\_\_\_\_ Director of Engineering \_\_\_\_\_



## DOCUMENT 00520

### AGREEMENT

This Agreement, made this \_\_\_\_\_ day of \_\_\_\_\_, 2020, by and between **Little Rock Water Reclamation Commission by and through the Little Rock Water Reclamation Authority, Little Rock, Arkansas**, hereinafter called "Owner" and \_\_\_\_\_ doing business as (an individual,) (a partnership,) or (a Corporation,) hereinafter called "Contractor",

WITNESSETH: That for and in consideration of the payments and agreements herein after mentioned:

1. The Contractor will commence and complete the construction of: **Fourche Creek Water Reclamation Facility Industrial EQ Basin Rehabilitation**, for the price given in the Bid Form.
2. The Contractor will furnish all of the materials, supplies, tools, equipment, labor and other services necessary for the construction and completion of the Project described herein.
3. The Contractor will commence the work required by the Contract Documents within ten (10) calendar days after the date of the Notice to Proceed and will complete the same within 180 calendar days unless the period for completion is extended otherwise by the Contract Documents. The Contractor further agrees to pay as liquidated damages, the sum of \$1000 per day for each consecutive calendar day past Substantial Completion, then \$500 per day for each consecutive calendar day past Final Completion (30 days after Substantial Completion) as provided in Section 46 of the Supplemental General Conditions.
4. The Contractor agrees to perform all of the Work described in the Contract Documents and comply with the terms therein for the sum of:  
  
\_\_\_\_\_ Dollars (\$\_\_\_\_\_)
5. The term "Contract Documents" means and includes the Advertisement for Bids, Information for Bidders, Davis-Bacon Wage Determination(s), Bid Form, Bidder's Statement of Subcontractors, Statement of Bidder's Qualifications, Bid Bond, Agreement, General Conditions, Supplemental General Conditions, Payment Bond, Performance Bond, Warranty Bond, Notice of Award, Notice to Proceed, Contractor's Act of Assurance, DBE/MBE/WBE Certification and EPA Forms 6100-2, -3, and -4, Insurance, Certificate of Owner's Attorney, ANRC Approval of Contract, Change Orders, Drawings, Specifications and Addenda.





6. The Owner will pay to the Contractor in the manner and at such times as set forth in the Supplemental General Conditions such amounts as required by the Contract Documents.
7. This Agreement shall be binding upon all parties hereto and their respective heirs, executors, administrators, successors, and assigns.

IN WITNESS WHEREOF, the parties hereto have executed, or caused to be executed by their duly authorized official, this Agreement in five copies, each of which shall be deemed an original on the date first above written.

**OWNER:**

Little Rock Water Reclamation Commission  
By and Through  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

\_\_\_\_\_  
(Signature)  
Greg Ramon, Chief Executive Officer

**CONTRACTOR:**

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Print Name and Title)

\*ATTEST:

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Print Name and Title)



Address \_\_\_\_\_  
\_\_\_\_\_

Corporate Seal:

Employee Identification No. \_\_\_\_\_

Contractor License No. \_\_\_\_\_

\* If Contractor is a Corporation, the Secretary of the Corporation should Attest. Attach evidence of authority to sign





DOCUMENT 00550

**NOTICE TO PROCEED**

To: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Date: \_\_\_\_\_

Project Description: **Fourche Creek WRF Industrial EQ Basin Rehab**  
**Little Rock Water Reclamation Authority**  
**Little Rock, Arkansas**  
**Owner's Project Number: 7190700**

You are hereby notified that the Contract Time under the above Contract will commence to run on \_\_\_\_\_, 20\_\_\_. By that date, you are to start performing your obligations under the Contract Documents. In accordance with Article 3 of the Agreement, the date of Final Completion is \_\_\_\_\_, 20\_\_\_.

Before you start any Work at the site, Paragraph 2.7 of the General Conditions provides that you must deliver to the Owner Certificates of Insurance which you are required to purchase and maintain in accordance with the Contract Documents.

Dated this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_.

Owner:  
Little Rock Water Reclamation Commission  
By and Through Little Rock Water Reclamation Authority

By: \_\_\_\_\_  
(Signature)

Title: \_\_\_\_\_

**Acceptance of Notice**

Receipt of the above Notice to Proceed is hereby acknowledged:

Dated this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_.

By: \_\_\_\_\_

Title: \_\_\_\_\_





DOCUMENT 00610

PERFORMANCE BOND

Bond Number: \_\_\_\_\_

KNOW ALL MEN BY THESE PRESENTS, That

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Address of Contractor)

a \* \_\_\_\_\_, hereinafter called "Principal", and  
(\*Corporation, Partnership, or Individual)

\_\_\_\_\_  
(Name of Surety)

\_\_\_\_\_  
(Address of Surety)

hereinafter called "Surety", are held and firmly bound unto

Little Rock Water Reclamation Commission  
acting by and through the  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

hereinafter called "Owner", in the total aggregate penal sum of

\_\_\_\_\_ Dollars (\$ \_\_\_\_\_)  
in lawful money of the United States, for the payment of which sum well and truly to be  
made, we bind ourselves, our heirs, executors, administrators, successors, and assigns,  
jointly and severally, firmly by these Presents.

The condition of this obligation is such that whereas, the Principal entered into a certain  
Contract with the Owner, dated \_\_\_\_\_, \_\_\_\_\_, a copy of which is  
hereto attached and made a part hereof for the construction of:

**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQ BASIN  
REHABILITATION**

NOW, THEREFORE, if the Principal shall well, truly and faithfully perform its duties, all  
the undertakings, covenants, terms, conditions, and agreements of said contract during





the original term thereof, and any extensions thereof which may be granted by the OWNER with or without notice to the Surety and during the one year guaranty period and if the Principal shall satisfy all claims and demands incurred under such contract, and shall fully indemnify and save harmless the OWNER from all costs and damages which it may suffer by reason of failure to do so, and shall reimburse and repay the OWNER all outlay and expense which the OWNER may incur in making good any default, then this obligation shall be void, otherwise to remain in full force and effect.

PROVIDED, FURTHER, that the said Surety, for value received hereby stipulates and agrees that no change, extension of time, alteration or addition to the terms of the contract or to WORK to be performed thereunder or the SPECIFICATIONS accompanying same shall in any way affect its obligation on this BOND, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the contract or to the WORK or to the SPECIFICATIONS.

PROVIDED, FURTHER, that it is expressly agreed that the Bond shall be deemed amended automatically and immediately, without formal and separate amendments hereto, upon amendment to the Contract not increasing the contract price more than 20 percent, so as to bind the Principal and the Surety to the full and faithful performance of the Contract as so amended. The term "Amendment", wherever used in this Bond, and whether referring to this Bond, the Contract or the Loan Documents shall include any alteration, addition, extension, or modification of any character whatsoever.

PROVIDED, FURTHER, that no final settlement between the OWNER and the PRINCIPAL shall abridge the right of the other beneficiary hereunder, whose claim may be unsatisfied. The Owner is the only beneficiary hereunder.



IN WITNESS WHEREOF, this instrument is executed in five (5) counterparts, each one of which shall be deemed an original, this the \_\_\_\_ day of \_\_\_\_\_, 2020.

**PRINCIPAL:**

\_\_\_\_\_  
(Company)

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
(Surety)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

By: \_\_\_\_\_  
(Signature Attorney-in-Fact)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**SEAL**

**ATTEST:**

By: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**NOTE:** Date of BOND must not be prior to date of Contract. If CONTRACTOR is a Partnership, all Partners must execute this BOND.

**IMPORTANT:** Surety companies executing BONDS must appear on the Treasury Department's most current list (Circular 570 as amended) and be authorized to transact business in the State of Arkansas.





**SECTION 00612**

**WARRANTY BOND**

Bond Number: \_\_\_\_\_

KNOW ALL MEN BY THESE PRESENTS, That

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Address of Contractor)

a \* \_\_\_\_\_, hereinafter called "Principal", and  
(\*Corporation, Partnership, or Individual)

\_\_\_\_\_  
(Name of Surety)

\_\_\_\_\_  
(Address of Surety)

hereinafter called "Surety", are hereby jointly and severally held and firmly bound unto

Little Rock Water Reclamation Commission  
acting by and through the  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

as Obligee ("Owner"), for the payment of the total aggregate penal sum of  
\_\_\_\_\_ Dollars (\$\_\_\_\_\_) )  
subject to the terms and conditions provided herein.

WHEREAS, Principal executed and entered into that certain Agreement with Owner for:

**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL  
EQUALIZATION BASIN REHABILITATION**

dated \_\_\_\_\_, 20\_\_\_\_ (the "Contract"), the provisions of which are  
incorporated herein by reference, and unless otherwise defined herein all defined terms  
used or referred to herein shall have the meaning ascribed thereto in the Contract. In  
addition to other obligations and liabilities, the Contract required Principal to perform the



work for the Project and to furnish this Bond to Owner in compliance with Section 22 of the General Conditions and the RLF Supplemental General Conditions.

NOW THEREFORE, the obligations of Principal and Surety herein shall remain in full force and effect as provided herein, subject to becoming null and void upon the occurrence of either or both of the conditions that (a) Principal shall fully perform and satisfy all obligations and liabilities of Principal under the warranty and guarantee provisions of Sections 22.1 and 22.2 of the General Conditions, as modified or supplemented by the RLF Supplemental General Conditions or any other applicable Contract Documents, at any time within one year after the date of Final Acceptance or such longer period of time as may be prescribed therein (the "Warranty Period"), all of which includes without limitation either correcting the defective Work, or removing and replacing it with nondefective Work, or paying all direct, indirect or consequential costs of such correction or removal and replacement, all as provided therein, or (b) Owner shall fail to institute a lawsuit, action or other proceeding under this Bond before the expiration of three (3) months following the end of the Warranty Period.

FURTHER PROVIDED, that (a) any changes, modifications, amendments, alterations or supplementations in or to the Contract, and Contract Documents or the Work, or the giving by Owner of any extension of time for the performance of the Contract, or any other forbearance on the part of either Owner or Principal to the other, shall not in any way release the Principal or Surety, or either of them, from their liability hereunder, notice to the Surety of any of the foregoing being hereby waived, (b) in no event shall the aggregate liability of Surety exceed the amount set out herein, and (c) the rights and obligations hereof shall be binding upon and shall inure to the benefit of Principal, Surety, Owner and their respective heirs, legal representatives, partners, privies, successors and assigns, provided that nothing herein shall authorize the assignment of any such rights and obligations except upon compliance with Section 23 of the General Conditions.

Date of project final completion is \_\_\_\_\_. The bond shall be effective for a period of one year.



IN WITNESS WHEREOF, this instrument is executed in five (5) counterparts, each one of which shall be deemed original, this the \_\_\_\_\_ day of \_\_\_\_\_ 20 \_\_\_\_.

**PRINCIPAL:**

\_\_\_\_\_  
(Company)

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

**SURETY:**

\_\_\_\_\_  
(Surety)

Address: \_\_\_\_\_

\_\_\_\_\_

Phone No. \_\_\_\_\_

By: \_\_\_\_\_  
(Signature Attorney-in-Fact)

Address: \_\_\_\_\_

\_\_\_\_\_

Phone No. \_\_\_\_\_

**SEAL**

**ATTEST:**

By: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

**IMPORTANT:** Surety Companies executing BONDS must appear on the Treasury Department's most current list (Circular 570 as amended) and be in accordance with Section 16 of the RLF Supplemental General Conditions and be authorized to transact business in the State of Arkansas.





DOCUMENT 00615

**PAYMENT BOND**

Bond Number: \_\_\_\_\_

KNOW ALL MEN BY THESE PRESENTS, That

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Address of Contractor)

a \* \_\_\_\_\_, hereinafter called "Principal", and  
(\*Corporation, Partnership, or Individual)

\_\_\_\_\_  
(Name of Surety)

\_\_\_\_\_  
(Address of Surety)

hereinafter called "Surety", are held and firmly bound unto

Little Rock Water Reclamation Commission  
acting by and through the  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

hereinafter called "Owner" and unto all persons, firms and corporations who or which may furnish labor, or who furnish materials to perform as described under the contract and to their successors and assigns in the total aggregate penal sum of \_\_\_\_\_

\_\_\_\_\_ Dollars (\$\_\_\_\_\_) in lawful money of the United States, for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors, and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION is such that whereas, the Principal entered into a certain Contract with the Owner, dated \_\_\_\_\_, \_\_\_\_\_ a copy of which is hereto attached and made a part hereof for the construction of:

**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQUALIZATION  
BASIN REHABILITATION**





Now, therefore, if the Principal shall promptly make payment to all persons, firms, and corporations furnishing materials for or performing labor in the prosecution of the Work provided for in such contract, and any authorized extensions or modification thereof, including all amounts due for materials, lubricants, oil, gasoline, coal and coke, repairs on machinery, equipment and tools, consumed or used in connection with the construction of such Work, and for all labor cost incurred in such Work including that by a Subcontractor, and to any mechanic or materialman lienholder whether it acquires its lien by operation of State or Federal law; then this obligation shall be void, otherwise to remain in full force and effect.

PROVIDED, that beneficiaries or claimants hereunder shall be limited to the Subcontractors, and persons, firms and corporations having a direct contract with the Principal or its Subcontractors.

PROVIDED, FURTHER, that the said Surety for value received hereby stipulates and agrees that no change, extension of time, alteration or addition to the terms of the contract or to the Work to be performed thereunder or the Specifications accompanying the same shall in any way affect its obligation on this Bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of this contract or to the Work or to the Specifications.

PROVIDED, FURTHER, that no suit or action shall be commenced hereunder by any claimant: (a) Unless claimant, other than one having a direct contract with the Principal, shall have given written notice to any two of the following: The Principal, the Owner or the Surety above named within ninety (90) days after such claimant did or performed the last of the work or labor, or furnished the last of the materials for which said claim is made, stating with substantial accuracy the amount claimed and the name of the party to whom the materials were furnished, or for whom the work or labor was done or performed. Such notice shall be served by mailing the same by registered mail or certified mail, postage prepaid, in an envelope addressed to the Principal, Surety, at any place where an office is regularly maintained for the transaction of business, or served in any manner in which legal process may be served in the State in which the aforesaid project is located, save that such service need not be made by a public officer. (b) After the expiration of one (1) year following the date of which Principal ceased work on said Contract, is being understood, however, that if any limitation embodied in the Bond is prohibited by any law controlling the construction hereof, such limitation shall be deemed to be amended so as to be equal to the minimum period of limitation permitted by such law.

PROVIDED, FURTHER, that it is expressly agreed that this Bond shall be deemed amended automatically and immediately, without formal and separate amendments hereto, upon amendment to the Contract not increasing the contract price more than 20 percent, so as to bind the Principal and the Surety to the full and faithful performance of the Contract as so amended. The term "Amendment", whenever used in this Bond and whether referring to this Bond, the contract or the loan Documents shall include any alteration, addition, extension or modification of any character whatsoever.

PROVIDED, FURTHER, that no final settlement between the Owner and the Contractor



shall abridge the right of any beneficiary hereunder, whose claim may be unsatisfied.

IN WITNESS WHEREOF, this instrument is executed in five (5) counterparts, each one of which shall be deemed an original, this the \_\_\_\_\_ day of \_\_\_\_\_, 2020.

**PRINCIPAL:**

\_\_\_\_\_  
(Company)

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
(Surety)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

By: \_\_\_\_\_  
(Signature Attorney-in-Fact)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**SEAL**

**ATTEST:**

By: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**NOTE:** Date of BOND must not be prior to date of Contract. If CONTRACTOR is a Partnership, all Partners must execute this BOND.

**IMPORTANT:** Surety Companies executing BONDS must appear on the Treasury Department's most current list (Circular 570 as amended) and be in accordance with Section 16 of the RLF Supplemental General Conditions and be authorized to transact business in the State of Arkansas.





## SECTION 01000

### BASIC REQUIREMENTS

#### PART 1 - GENERAL

##### 1.1 DESCRIPTION AND SCOPE OF WORK

- A. The work included in this Contract consists of the furnishing of all tools, labor, equipment, materials, and supplies necessary to fully construct to the satisfaction of the Engineer and Owner the FCWRF FOG Receiving Station Project together with all incidental and ancillary work as shown on the Drawings. Installation is to be complete and inclusive of pipe, fittings, service connections, excavation, trenching, bedding material, backfill material, concrete, manholes, connection to existing lines(s), acceptance testing, traffic control, trench safety, and restoration of streets and property.
- B. Whenever in these Documents the word "Owner" appears, it shall be understood to mean the Little Rock Water Reclamation Commission acting by and through Little Rock Water Reclamation Authority.
- C. Work or material not specifically mentioned in the Specifications, but designated on the Drawings, or forming an essential part of the Work mentioned or designated, shall be furnished and installed by the Contractor as though specifically mentioned.
- D. Construction of the work shall be by one General Contractor, utilizing Subcontractors for those specialties and portions of the Work that the General Contractor chooses to subcontract. All Subcontractors are subject to approval by the Engineer and Owner in accordance with applicable sections of the General Conditions and Supplemental General Conditions to these Specifications. The General Contractor shall maintain a responsible representative on-site whenever his subcontractors are on-site and engaged in the Work.
- E. The Drawings show the proposed location and details of construction work in this Contract. All work shall be performed by the Contractor in a thorough and workmanlike manner, in full accordance with the Drawings and Specifications by skilled and competent workmen well experienced in such construction methods and techniques.
- F. Any reference in these Specifications to an engineering standard (such as ASTM or AWWA) shall be to the latest version or edition as of the Bid Date.
- G. The Contractor shall not be permitted to sublet, sell or assign this contract or sublet any of the work to be performed hereunder without the written consent of the Owner (by and through the Engineer) and any such assignment or subletting of any such work without said consent shall be null and void and without force and effect. The Owner shall have the right to assign in whole or in part its rights hereunder.
- H. **The Little Rock Water Reclamation Authority "Standard Specifications for Design and Construction of Sewer Lines, Latest Edition" and the Little Rock Water Reclamation Authority Standard Details included in the Appendix, shall be a fundamental component of these Contract Documents and all provisions of the document and details shall be followed, unless otherwise shown on the Drawings or modified in the Specifications, or as directed by the Engineer.**



## COPIES OF DRAWINGS AND SPECIFICATIONS

- A. The Contractor will be provided sufficient copies of the Drawings and Specifications at no cost to the Contractor.

### 1.3 PERMIT(S)

- A. The Contractor shall be responsible for securing any required permit for the construction of the Project. Permits that may be required include but are not limited to City of Little Rock, Arkansas Highway and Transportation Department, and Arkansas Department of Environmental Quality Storm Water.
- B. A copy of all executed permits obtained for the Work in this project shall be submitted to the Engineer within five (5) days of Contractor receiving approval. Any permit process requiring involvement with the Owner shall be submitted to the Engineer for processing. The Owner shall have 14 days to process and execute any permitting related requests.

### 1.4 WRITTEN NOTICES

- A. Written notices, when required by the Contract Documents or for purposes of project administration, shall be mailed by Certified Mail, return receipt requested, as follows:
  - 1. If to the Owner: Little Rock Water Reclamation Authority  
Attn: Cary Beth Lipscomb, P.E.  
11 Clearwater Drive  
Little Rock, Arkansas 72204
  - 2. If to the Contractor: At the address as stated in the Agreement.

### 1.5 EXISTING UTILITIES AND SUBSURFACE STRUCTURES

- A. The construction work encompassed in this Contract will require excavation and related activity in close proximity to existing buried utility lines and subsurface structures (and some aerial facilities). The approximate location of such utilities and structures is shown on the Drawings, but all such utilities, structures, and individual service lines are not shown. The Contractor is to be aware of the potential for such buried utility lines and structures conflicting with his intended construction efforts, and use proper precautionary measures to locate, verify, and protect such buried lines and structures so as to avoid damage.
- B. Information and data reflected on the Drawings with respect to underground facilities at or contiguous to the site is based upon information and data furnished to Owner and Engineer by owners of such underground facilities or others, and Owner and Engineer do not assume responsibility for the accuracy or completeness thereof. Provisions concerning responsibilities for the adequacy of data furnished to the Contractor on subsurface conditions, underground facilities and other physical conditions, and possible changes in the Contract Documents due to differing conditions appear in the Supplemental General Conditions and/or General Conditions.
- C. The Contractor shall contact the owners of the various existing buried utility lines (or aerial facilities) and structures as impacted by his construction activities, and obtain their assistance in identifying, locating, and marking affected facilities prior to beginning any excavation which might endanger the existing facilities. The Contractor will bear all costs in connection with the location, marking, temporary protection, or support of such utility facilities. If such utilities are damaged or impaired due to the actions or omissions of the Contractor, then the Contractor is responsible for the cost of repairs or replacement of the affected or damaged utility lines.



- D. The Contractor shall make necessary exploratory excavations to determine the location of underground structures such as pipes, drains, conduits, and other structures.
- E. The Contractor shall provide adequate protection and support for all surface and subsurface structures or other facilities encountered during the progress of the work.
- F. The Contractor must comply with the ARKANSAS ONE-CALL (811) system, and alert the Utility Systems accordingly.
- G. The Contractor shall be responsible for any damage to the Owner's equipment and facilities resulting from Contractor's negligence. Contractor shall make immediate repairs to damages at his expense. In the event service has been disrupted, immediate repair operations shall be continuous and around the clock until complete, if necessary.
- H. If any utility facility or structure is damaged during the progress of the work, the Contractor shall immediately notify the appropriate owner. Repairs shall not be made by the Contractor without the prior approval of the utility facility or structure owner. The Contractor shall provide available assistance to the utility involved in making repairs under emergency conditions.

#### 1.6 SAFETY REQUIREMENTS

- A. Contractor shall be totally responsible for all necessary safety measures and precautions as stipulated in the General Conditions to these Specifications, and in compliance with the Occupational Safety and Health Administration's (OSHA) requirements applicable to the work of the various kinds as called for under this Contract. Particular attention is called to the Appendix of these Specifications pertinent to Excavation and Trench Safety.
- B. The Contractor shall be totally responsible for providing and maintaining any necessary and required barricades, safety fences, signs, markers, shoring, bracing, etc. to provide for the protection of workmen and the Owner's personnel during the duration of the Work under this Contract.

#### 1.7 ENVIRONMENTAL ASPECTS

- A. The work shall be planned and executed in full compliance with the requirements of the Federal Environmental Protection Agency (EPA), the Arkansas Department of Environmental Quality (ADEQ), and all local authorities.
- B. Dust Control: During periods of dry, dusty conditions at the construction site, the work shall be planned and executed so as to minimize dust problems. Contractor shall provide for watering of the construction site, haul roads, and any other disturbed areas to prevent excessive dust problems within the vicinity. Failure of the Contractor to provide adequate dust control shall be just cause for stopping all other work until the areas causing the dust have been watered and the dust controlled. Water for such dust control shall be provided by the Contractor.
- C. Noise Control: The work shall be planned and executed to minimize noise on the construction site. All applicable measures for noise control as required by OSHA standards shall be used.
- D. Burning: Logs, limbs, tops, stumps, roots and other debris may be burned in approved designated areas with the approval of all applicable local authorities, including the City of Little Rock Fire Department, and City of Little Rock ordinances. All state and local laws pertaining to controlled burning must be followed. No burning shall occur in a maintained landscape. No scrap paper, cans, scrap pipe, etc. may be burned. If the Contractor is not allowed to burn the above-mentioned items, then all debris from clearing operations



shall be hauled off site for disposal. Contractor will be responsible for disposal of all such debris in an approved disposal area.

#### 1.8 STORM WATER PERMIT, POLLUTION PREVENTION PLAN AND SILTATION CONTROL

- A. The work shall be so planned and executed so as to prevent siltation of area streams, ditches, swales, and drainages. Barriers, silt fences and filters shall be constructed as necessary by the Contractor to intercept and impede silt or debris laden runoff from the construction site and prevent excessive quantities of silt and debris from reaching area streams and drainages.
- B. **Contractor shall complete for the Owner, all Storm Water Permit forms (if required) as required by the Arkansas Department of Environmental Quality (ADEQ). The Contractor shall submit all forms to the Engineer for Owner signature and forwarding to ADEQ. The Contractor shall be responsible for any and all fees, notices, notice of intent, notice of termination, disclosure statements, storm water pollution prevention plan, etc. associated with obtaining the Storm Water Permit. Contractor shall prepare the storm water pollution prevention plan (if required) and send to the Engineer for Owner signature and forwarding to ADEQ. Refer to specification Section 01573 Temporary Erosion and Sediment Control.**
- C. Contractor shall be responsible for the cost of all claims, losses, fines, penalties, or damages charged to Owner due to Contractor's failure to comply with the requirements of the Storm Water Permit. If requested, Contractor shall provide copies of the storm water permit, notices, and storm water pollution prevention plan to the Owner.
- D. Contractor shall follow all requirements of the Storm Water Pollution Prevention Plan and Storm Water Permit. The Owner reserves the right to stop all work if the Storm Water Pollution Prevention Plan is not being properly implemented and followed and if the Storm Water Permit forms are not kept up to date by the Contractor.

#### 1.9 FLOW CONTROL AND BYPASS PUMPING

- A. When the flow of sewage in the sewer line section under construction is above the maximum for proper execution of the work, flows shall be reduced to an acceptable level through plugging, blocking and bypass pumping of the flows.
- B. When the sewage flow is blocked or plugged, sufficient precautions shall be taken to protect the public health and protect sewer lines from damage. No sewage shall be allowed to backup into any homes or building. No sewage shall overflow any manhole, cleanout, or any other sewer access. Users upstream of the replacement area shall be able to use all of their water and sewer utilities without interruption. During any time when an active sewer is plugged or blocked, the Contractor shall observe the conditions upstream of the plug and be prepared to immediately start bypass pumping if needed.
- C. When bypass pumping is required, the Contractor shall provide the necessary pumps, conduits, and other equipment to divert the flow of sewage around the section in which work is to be performed. The bypass system shall be of sufficient capacity to handle existing flow plus additional rainfall induced flow. An additional stand-by pump shall be on-site in case of a pump failure.
- D. The Contractor shall properly operate and maintain any active bypass system. Pumps and equipment shall be continuously monitored by an employee capable of starting, stopping, refueling, and maintaining the pumps during the entire period for which bypass pumping is necessary. If pumping is required on a 24-hour basis, engines shall be equipped in a manner to keep noise to a minimum and within local required levels.





- E. Any pump operated by the Contractor which pulls sewage or any type of material out of a manhole or sewer shall discharge this material into another manhole or appropriate container. Under no circumstances shall this material be discharged, stored, or deposited on the ground, street, road, or open environment.
- F. The Contractor shall take appropriate steps to ensure that all pumps, piping, and hoses that carry sewage are protected from traffic.
- G. The Contractor shall be responsible for having sufficient pumping capacity on site in case of an emergency, i.e. a broken water line. Under no circumstances shall groundwater, surface water, drinking water, or any other water source other than sewage be discharged into the sanitary sewer collection system.
- H. Temporarily plugging a sewer line shall be approved by the Engineer and Owner.
- I. If requested by the Owner or Engineer, Contractor shall submit details of bypass plan.
- J. Immediately contain raw sewage spills and overflows caused by construction work. Contractor shall adhere to Little Rock Water Reclamation Authority's SSO procedures regarding appropriate response, cleanup, disinfection, and notification. Contractor shall conduct SSO procedures, at the behest of Little Rock Water Reclamation Authority, or shall assist Little Rock Water Reclamation Authority crews with SSO procedures. The Contractor shall be responsible for any and all fines, fees, expenses, labor costs, material costs, or settlements with property owners. Contractor shall at no time attempt to address SSO's without Owner's assistance or without notification to the Engineer or the Engineer's Representative. Repetitive SSO events shall not be tolerated and Contractor may face legal and/or civil action suits for such cases.
- K. Contractor shall immediately report any sanitary sewer spills and overflows onto any surface to the Engineer or the Engineer's Representative. No surfaces or amounts are exempt. Provide completed Sanitary Sewer Overflow (SSO) event information to the Engineer or Engineer's Representative by the end of work day. Include the following information: date of incident, specific location, start and stop times, the duration, volume, description of cause, whether overflow went into a waterway, impact (or possible impact) to area or environment, contact information of property owner (if known), contact information of construction crew and Contractor's foreman, resolution of SSO incident, how future reoccurrences will be prevented, and any other information pertinent to the SSO event or as requested by the Engineer.
- L. At Engineer and/or Owner's request, Contractor shall post notices of SSO event any time there is a chance of public exposure, when a SSO occurs in close proximity to a waterway, is 10,000 gallons or greater, or if possibility of human contact. Do not remove posted notices while evidence of the SSO remains. The SSO notice shall be posted for the following durations: a) Post for 2 weeks for SSO up to 100,000 gallons; or b) Post for 30 days for SSO greater than 100,000 gallons. Engineer shall direct Contractor of further notification requirements, which shall occur no more than 24-hours after the event and may require the Contractor personally notifying Schools, Hospitals, Daycare Centers, Elder Care centers, and similar areas when a SSO has occurred within close proximity (500-feet) of any of such facilities.

#### 1.10 CONSTRUCTION CONTROL, LAYOUT, AND SCHEDULING

- A. All work shall be constructed in accordance with the lines and grades shown on the Drawings. Elevations of existing ground, structures, and appurtenances, and existing utilities are believed to be reasonably correct as shown but are not guaranteed to be absolute and therefore are presented only as an approximation. Any error or apparent discrepancy in the data shown or omissions of data required for accurately locating the





work shall be referred immediately to the Engineer for interpretation or correction.

- B. The Contractor is responsible for all construction layout and both horizontal and vertical control of construction operations at all construction sites. The Engineer will provide surveys to establish reference points and benchmarks which are in the Engineer's judgement necessary to enable the Contractor to proceed with the work. Contractor shall report to the Engineer when any reference point is lost or destroyed. The Contractor shall furnish necessary assistant(s) to serve as rodman/chainman. Such assistant(s) to be provided by the Contractor shall be at no additional cost to the Owner or the Engineer. Contractor will be responsible for all street, drainage, and pipeline grade control. Contractor will set all grade stakes, slope stakes, etc. as necessary for the proper control of construction effort; all in such manner as to complete the structures and facilities to such line and grade as established on the Drawings or as directed by the Engineer and Owner.
- C. The Contractor shall be responsible for resetting all property pins disturbed by construction activities. All survey work for replacing property markers shall be done by a Licensed Surveyor.
- D. The Contractor shall carefully preserve benchmarks, reference points and stakes and in case of willful or careless destruction, the Contractor shall be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.
- E. The Contractor shall prosecute the construction of said work with due diligence and at such a rate and in such manner as in the opinion of the Engineer and Owner is necessary for completion within a reasonable time. The Contractor shall not open up work to the prejudice of work already started and shall arrange its work and dispose of materials so as to insure the least possible interference and inconvenience to the land owners on or beside whose property the pipelines are being constructed or to the public where the pipelines lie in or near a public thoroughfare. Contractor shall employ such number of construction crews as are necessary to construct said project within the allotted time provided.

#### 1.11 NORMAL PROJECT WORKING HOURS

- A. Normal project working hours for this project are Monday through Friday between the hours of 7:00 am and 7:00 pm. Work shall not be permitted on Saturday, Sunday, or any of the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day, unless written permission is requested by the Contractor and approved by the Engineer and Owner at least 48 hours prior to work taking place. The Owner will require that a representative of the Owner be present or available for work which occurs outside of the normal project working hours. The Contractor shall compensate the Owner for salary costs and expenses incurred by the Owner as a result of the Contractor choosing to work outside the normal project working hours.
- B. The Contractor shall compensate the Owner for the salary costs and expenses incurred as a result of the Contractor choosing to work outside the normal project working hours as follows:
  - 1. Labor costs multiplied by 3 plus expenses such as lodging, mileage, materials, meals, etc.
- C. The Contractor may perform clean-up work outside of regular hours with the approval of the Engineer and Owner. Clean-up work shall be approved by the Engineer and Owner at least 48 hours prior to work taking place.



#### 1.12 APPLICATION FOR PAYMENT

- A. Refer to specifications in Division 00 for further information regarding Application for Payment and Payments to Contractor.
- B. At least ten days before each progress payment falls due (but not more often than once a month), the Contractor shall submit an itemized list of quantities to the Engineer utilizing Unit Prices and a schedule of values for Application for Payment. Contractor shall review quantities and stored materials with Engineer's Representative prior to submitting Application for Payment to the Engineer. The deadlines for all disbursements will be discussed at the preconstruction conference. Disbursement requests not received by the Engineer prior to the deadlines established in the preconstruction conference may not be processed and paid until the following month.
- C. The estimate shall show a detailed breakdown of the amount of work completed previously, amount of work completed this period, amount of work completed to date, the amount of retainage, and the quantity and value of materials and equipment currently stored on site that have not been incorporated into the work. Partial payment requests shall include a copy of the updated construction schedule.
- D. Pay Periods: Calendar Month.
- E. Contractor shall submit to the Engineer for review, a detailed schedule of construction progress indicating the sequence of work, time of starting and anticipated completion of each part, and any unusual or critical aspects of the construction scheduling. The schedule shall include provisions for maintenance of traffic. Schedule may be of graphic form indicating time elements for the various portions of work. Revise and resubmit schedule as required.
- F. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at or near the site, the partial payment estimate shall also be accompanied by such supporting data, satisfactory to the Engineer, as will establish the Owner's title to the material and equipment and protect the Owner's interest therein, including applicable insurance
- G. This project is federally funded through the State Revolving Loan Fund (RLF) and is being administered by the Arkansas Natural Resources Commission (ANRC). Disbursements from the State Revolving Loan Fund (RLF) Programs shall be made monthly based upon actual work performed and materials stored on site less retainage.
- H. Partial payment requests shall include a certification by the Contractor that it has complied with all labor standards. The Contractor shall provide the Engineer a letter with each pay request certifying wages, through payroll review and employee interviews, meet the Davis-Bacon Requirements of this contract. Copies of payroll documents and completed interviews will be forwarded to the Engineer, if requested.

#### 1.13 CONFERENCES, PUBLIC MEETINGS AND NOTICES

- A. The Engineer will schedule a preconstruction conference after Notice of Award. Project progress meetings may be held periodically.
- B. Contractor shall be available to attend public meetings at the Engineer and Owner's request.
- C. Contractor shall prepare and deliver notices necessary for the performance of the Work. Contractor shall coordinate the content of the notice with the Owner. Every reasonable



effort shall be made to distribute notices two (2) days prior to any Work, however, Owner will allow the Contractor to distribute notices up to a minimum of one day in advance of Work.

- D. Contractor may distribute notices up to a maximum of fourteen (14) days prior to Work. If conditions do not allow Work to be performed during this period, Contractor will redistribute notices. If redistribution of notices is required, Work may be performed within one (1) day of noticing. The Owner, Little Rock Fire Department, Little Rock Police Department, and Little Rock Information 311 shall be notified daily of any Work via email, fax, or other approved method.
- E. Contractor vehicles, equipment, and machinery shall have an identifying logo in a visible location. Any contractor employee working on-site shall wear an identification badge which shall include a photo, name, company, and role/title.

#### 1.14 QUALITY ASSURANCE

- A. Maintain quality control over suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of specified quality.
- B. Comply fully with manufacturer's instructions.
- C. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- D. The Contractor shall supervise and direct the Work. The Contractor shall be solely responsible for the means, methods, techniques, sequences and procedures of construction. The Contractor shall employ and maintain on the Work a qualified supervisor or superintendent who shall have been designated by the Contractor as the Contractor's representative at the site. The supervisor shall have full authority to act on behalf of the Contractor and all communications given to the supervisor shall be as binding as if given to the Contractor. The supervisor shall be present on the site at all times as required to perform adequate supervision and coordination of the Work. The Engineer and Owner shall have the right at all times to require the removal of any superintendent, foreman, or workman for performing inferior work.
- E. Should any work be performed by the Contractor without giving notice of plan of work and opportunity of inspection by the Engineer and Owner or his representative, the Engineer and/or Owner may require the Contractor to uncover such work at his own expense for examination by the Engineer. The cost of uncovering such work shall be the responsibility of the Contractor, whether or not the work is found acceptable. The work shall be subject to inspection by other appropriate AHTD, City, County, State, Federal or other governmental inspectors at all times.
- F. The methods, equipment, and appliances shall produce a satisfactory quality of work and shall be adequate to maintain the schedule of progress. The Contractor shall maintain all equipment in good repair to ensure efficient performance of the work required. The Engineer and Owner shall have the right to require the removal and/or replacement of any equipment which he deems incapable of satisfactory performance.

#### 1.15 MAINTENANCE OF TRAFFIC

- A. The Contractor shall maintain traffic and protect the public from all damage to persons and property in accordance with all applicable State, City, and County regulations. Contractor shall conduct his operations so as to maintain and protect access, for vehicle and pedestrian traffic, to and from all properties adjoining or adjacent to those streets



affected by his operations, and to subject the public to a minimum of delay and inconvenience.

- B. Suitable signs, barricades, danger lights, etc., shall be erected and the work outlined by adequate lighting at night in order to protect persons from injury and avoid property damage. The Contractor shall provide qualified flagmen to direct traffic while working upon a highway, street, or road over which traffic must pass.
- C. Traffic shall be detoured as required; however, no traffic shall be detoured without prior knowledge and approval of the traffic control agency having jurisdiction. Contractor shall notify the Engineer at least 24 hours in advance of the time he proposes to detour traffic. No street shall be completely blocked, nor blocked more than one-half at any time without specific authorization. Any pavement markings damaged during the Work shall be removed and replaced promptly by the Contractor.
- D. Traffic control shall be in accordance with City of Little Rock and/or the Arkansas Department of Transportation Standard Specifications, latest edition. Traffic control shall be in accordance with the agency having jurisdiction within the area of work.
- E. Closing streets with one access route shall not be acceptable or permitted. One traffic lane shall remain open at any given time. Excavated areas within the traffic lanes of highways, streets, roads, and pedestrian walkways shall be backfilled as soon as possible and the area reopened to traffic.
- F. The Contractor shall be responsible for making provisions for the safe and free passage of persons and vehicles by, over, or around the work while it is in progress. Such provisions or traffic control plans shall be satisfactory with the Engineer, Owner, State, County, and Local authority having jurisdiction within the area of work.
- G. The Contractor shall make the same provisions as described above for the passage of vehicular and pedestrian traffic between private property and public highways, streets, and roads that are satisfactory to the Engineer, Owner and private property owners involved.
- H. Contractor shall obtain street closing permits from State, County, City or Local authority having jurisdiction within the area of work. Copies of all permits shall be provided to Engineer.
- I. Contractor shall notify law enforcement agencies, fire departments, and other impacted agencies and personnel.
- J. Contractor shall submit a barricade plan to traffic control agency having jurisdiction and Engineer.

#### 1.16 USE OF COMPLETED PORTIONS

- A. The Owner may take possession of and utilize certain elements of the project as they are completed and placed into operation by the Contractor. The Contractor shall allow the Owner use of completed portions of the Work as necessary to maintain an effective system. Contractor shall plan the Work accordingly, in close coordination with the Engineer and Owner so as to maintain all vital system operations.
- B. For Warranty purposes, the warranty period as called for by the General and Supplemental General Conditions to the Specifications will start upon substantial completion of the entire project.

#### 1.17 REFERENCES



- A. Conform to reference standard by date of issue current as of date of Contract.
- B. The applicable codes and standards referred to in these specifications shall establish minimum requirements for materials, equipment, and installation, except where more stringent requirements are called for on the Drawings or elsewhere in the Contract Documents. Any conflict between the referenced codes and standards and the Drawings and Specifications shall be resolved by the Engineer and Owner, whose decision shall be binding upon all parties. All codes and standards referenced shall be the latest revision at the time of bidding.

#### 1.18 TEMPORARY ELECTRIC POWER

- A. Contractor shall provide and pay for power services required from source.

#### 1.19 TEMPORARY WATER

- A. Little Rock Water Reclamation Authority is NOT the Owner of the potable water distribution system within the project limits. The Contractor shall contact the Owner (Central Arkansas Water) of the water distribution system in the area of construction.
- B. The Contractor shall connect to the water distribution system in accordance with all requirements of the owner of the water distribution system. The Contractor shall install a backflow prevention device and meter as required by the owner of the water distribution system.
- C. The Contractor shall be responsible for any fees and water use charges as may be charged to the Contractor by the owner of the water distribution system.
- D. **The Contractor shall not use individual homeowners or business utilities, including water, for construction activities.**

#### 1.20 SANITARY FACILITIES

- A. Contractor shall provide and maintain required sanitary facilities and enclosures for the appropriate handling and disposal of all human waste, solid waste, and construction waste.
- B. Maintain clean and sanitary conditions.

#### 1.21 TEMPORARY WATER CONTROL

- A. Maintain excavations and trenches free of water. Provide and operate pumping equipment of a capacity to control water flow
- B. Provide dewatering system and pumping to maintain excavations dry and free of water inflow on a 24-hour basis.
- C. Provide piping to handle pumping outflow to discharge in a manner to avoid erosion or deposit of silt.

#### 1.22 TEMPORARY ACCESS ROADS AND PARKING

- A. Construct and maintain temporary construction access roads, parking areas, and detours as are required to execute the Work.



#### 1.23 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

- A. Remove temporary erosion control construction, above grade or buried utilities, equipment, facilities, and materials, prior to Substantial Completion inspection.
- B. Remove and repair damage caused by installation or use of temporary work.

#### 1.24 CONTRACT CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and Work is complete in accordance with Contract Documents and ready for Engineer and Owner's inspection.
- B. Submit final Application for Payment identifying total adjusted Contract Price, previous payments, and amount remaining due.

#### 1.25 CLEANING AND DISPOSAL

- A. Maintain areas free of waste materials, debris, rocks, roots, stumps, limbs, and rubbish. Maintain site in a clean and orderly condition. No trash shall be burned or buried on the job site and shall be properly disposed of by the Contractor.
- B. Execute final cleaning prior to final inspection.
- C. Drainageways, street surfaces and shoulders, driveways, lawns and landscaping, culverts, and all areas affected by construction shall be restored to equal or better than original condition. Ditches and drainageways shall be left clean and unobstructed and restored to their original cross-section and grade. Culverts shall be left "open" and free-flowing.

#### 1.26 FENCE RESTORATION

- A. The Contractor shall be responsible for maintenance of fences during construction. The Contractor shall provide as necessary temporary fencing, gates, etc., as may be required to afford access to the construction site and maintain the full integrity of the fence.
- B. All fences disturbed by construction activity shall be restored to their original condition or better using fencing materials that are of the same size, metal gauge, lumber, and character as the original fence.

#### 1.27 CHANGE ORDER PROCEDURES

- A. Submit itemized list of quantities and supporting data to Engineer for preparation of change order.

#### 1.28 PROJECT RECORD DOCUMENTS

- A. Maintain on site, one set of Contract Documents, approved Shop Drawings, and Product Submittals to be utilized for record documents.
- B. Record actual revisions to the Work concurrent with construction progress.
- C. Specifications, Record documents, and Shop Drawings: Legibly mark each item to record actual construction or product installed.
- D. Submit documents to Owner with final Application for Payment.



.29

## RIGHT-OF-WAY

- A. The lands upon which the Work is to be performed, rights-of-way and easements for access thereto and other lands designated for use by Contractor in performing the Work are identified on the Drawings. All additional lands and access thereto required for temporary construction facilities or storage of materials and equipment are to be provided by Contractor. Easements for permanent structures or permanent changes in existing structures are to be obtained and paid for by Owner.
- B. Record actual revisions to the Work concurrent with construction progress.
- C. Specifications, Record documents, and Shop Drawings: Legibly mark each item to record actual construction or product installed.

## 1.30 RESTORATION OF INFRASTRUCTURE, IMPROVEMENTS, STRUCTURES, ETC.

- A. The Contractor shall be responsible for repairing and/or replacing any public or private infrastructure, retaining walls, streets, drives, sidewalks, miscellaneous pavements, landscaping, sodding, brick pavers, fencing, irrigation systems, utilities, etc. damaged or disturbed by the Contractor during construction of the project.
- B. All improvements damaged or disturbed by construction activity shall be restored to their original condition or better using materials that are of the same size, metal gauge, lumber, and character as the original improvement and/or structure.
- C. Contractor shall take necessary precautions to prevent disturbance to private property. Contractor shall use plywood sheets or other method to prevent rutting caused by equipment in yards and other areas used for access. All areas disturbed by construction activity and access shall be sodded or seeded in accordance with specifications and as shown on the Drawings. Contractor shall repair any ruts caused by construction activity.
- D. All repair and replacement work shall be as approved by Engineer and/or Owner.

## PART 2 - PRODUCTS

Not used.

## PART 3 – EXECUTION

Not used.

END OF SECTION





## SECTION 01220

### MEASUREMENT AND PAYMENT

#### PART 1 – GENERAL

##### 1.1 SECTION DESCRIPTION

- A. This Section stipulates the method of measurement and payment for items of Work for which Unit Prices and Lump Sum Prices are stated in the Bid Form.
- B. The bid item price shall include all Work, as required by the Contract Documents, to complete the specified work listed on the Bid Form. The Work shall include all labor, materials, equipment, tools, and other such incidentals as required.
- C. All Work not specifically set forth as a pay item on the Bid Form or addressed herein, but nonetheless required for the complete and successful performance of the Work, shall be considered an obligation of the Contractor and subsidiary to the principle contract unit price for bid items requiring such materials and/or work. The cost of such subsidiary work shall be considered as included in the unit bid price required for the successful completion of the principle items of work indicated, and will not be paid outside of, or in addition to, the pay items shown on the Bid Form.

##### 1.2 SCOPE OF PAYMENT

- A. Units of measurement of items of Work for which Unit and/or Lump Sum Prices are stated will be as herein subsequently defined.
- B. The estimated quantities for items of Work for which Unit Prices are given in the Bid Form are subject to variation, and payment shall be based upon the final measurement of the items of work actually successfully completed and accepted. This project is federally funded through the Clean Water State Revolving Loan Fund (RLF) and administered by the Arkansas Natural Resources Commission (ANRC). Approval of payment includes reviews by the funding agency (ANRC), the Engineer, and the Owner; as well as the submission of all required information for processing payment. Refer to specification Section 00700 "General Conditions" and Section 00712 "RLF Supplemental General Conditions" for information regarding approval of payment and the general payment review process. Section 00712 "RLF Supplemental General Conditions" shall govern in matters pertaining to the payment process if in conflict with Section 00700 "General Conditions".

##### 1.3 ESTIMATED QUANTITIES

- A. Quantities stipulated in the Bid Form or Contract Documents are approximate and are to be used only as a basis for estimating the probable cost of the Work and for comparing the bids submitted for the Work. The actual amounts of work done and materials furnished under unit price items may differ from the estimated quantities.
- B. Payments will be made, in accordance with the Contract Documents, for actual quantities utilized or installed, with said quantities being measured as specified herein. Each bid item will be measured and paid for by the units defined on the Bid Form, at the Item Unit Cost submitted and awarded.
- C. Contractor agrees that he will make no claim for damages, anticipated profits, or otherwise on account of any difference between the amounts of work actually performed, materials actually furnished, actual tools and equipment required and the estimated amounts thereof.



## MEASUREMENT AND PAYMENT

- A. **Item No. 1 – FOG Receiving Station.** Construction of the new FOG receiving station that includes a concrete slab, truck off-loading concrete pad, canopy, process equipment, and associated piping, electrical installation, and instrumentation. The station includes a truck off-loading pump (and uninstalled spare), a rock trap/grinder, a FOG storage tank, a heating and recirculation system, and a digester feed pump (and uninstalled spare). The heating and recirculation system includes a FOG recirculation pump, a water to FOG heat exchanger, and two hot water pumps.
- B. **Item No. 2 – Primary Digester No. 5 Mixing System.** Demolition of the existing primary digester no. 5 gas mixing system. Installation of a new pump mixing system that includes two pumps, mixing nozzles, and associated piping, electrical installation, and instrumentation. Repairs and modifications to building structures and digesters.
- C. **Item No. 3 – Primary Digester No. 6 Mixing System.** Demolition of the existing primary digester no. 6 gas mixing system. Installation of a new pump mixing system that includes two pumps, mixing nozzles, and associated piping, electrical installation, and instrumentation. Repairs and modifications to building structures and digesters.
- D. **Item No. 4 – Waste Gas Burner System.** Demolition of the three existing waste gas burners. Construction of a new waste gas burner system that includes a concrete slab, two waste gas burners with propane fueled ignition systems, sediment trap, and associated piping, electrical installation, and instrumentation.
- E. **Item No. 5 – Electrical Modifications.** Modifications required to provide electrical power to the FOG receiving station, primary digesters nos. 5 and 6 mixing systems, and new waste gas burner system.
- F. **Item No. 6 – Primary Digester No. 5 Cleaning.** Cleaning of primary digester no. 5 including dewatering, hauling and disposal of anaerobic digester contents.
- G. **Item No. 7 – Primary Digester No. 6 Cleaning.** Cleaning of primary digester no. 6 including dewatering, hauling and disposal of anaerobic digester contents.
- I. **Item No. 8 – Storm Water Permit, Pollution Prevention Plan and Siltation Control.** Preparation of the Storm Water Permit and Storm Water Pollution Prevention Plan, and siltation control, shall be paid for at the stated lump sum amount for the job requirement as stated in the Bid Form. The lump sum amount shall include all labor, equipment, tools, cost of storm water permit fees, preparation of storm water permit and pollution prevention plan, siltation control, barriers and filters, silt fencing, and compliance with all aspects of the storm water permit and pollution prevention plan, all work, equipment, materials, and other costs related to the work called for in Section 01573 "Temporary Erosion and Sediment Control" of these specifications. The lump sum amount shall be paid based upon the percentage of work that is completed.
- H. **Item No. 9 – Mobilization.** This item shall compensate the Contractor for mobilization to the site of work for the execution of the contract, and shall not limit site visits for completion of the Work and shall not prevent the Contractor from returning to the site of work multiple times. The bid amount for mobilization of 5% shall include all preparatory work, transportation, and operations necessary for movement of personnel, equipment, supplies, and incidentals to the various sites of work throughout the execution of the contract, at the frequency required to complete the Work. This bid item shall include all requirements for any establishment of temporary offices, storage locations or storage buildings, sanitary facilities, and other facilities, as necessary, to undertake the Project. Work and operations which must be performed, or for expenses incurred, prior to beginning work on the Project, and any preconstruction costs (not including bidding costs) and not directly attributable to other pay items in this Section, shall be incidental to this bid item. No additional payment shall be allowed for multiple mobilization operations, site visits, delivery, transportation, or other mobilization related activities, and shall be as required to provide a complete and functional system as required by the Contract Documents.

END OF SECTION





## SECTION 01573

### TEMPORARY EROSION AND SEDIMENT CONTROL

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. In all respects during prosecution of the Work called for by the Contract Documents, Contractor shall minimize the discharge of stormwater pollutants from the construction activity.
- B. The work shall be planned and executed so as to prevent siltation of area streams, ditches, swales, and drainages.
- C. Barriers and filters shall be constructed as necessary by the Contractor to intercept and impede silt or debris laden runoff from the construction site and prevent excessive quantities of silt and debris from reaching area streams and drainages.
- D. If disturbed area is greater than 1 acre, the Contractor shall complete all required forms in order for the Owner to obtain a National Pollution Discharge Elimination System (NPDES) Storm Water Permit and the Contractor shall prepare a Storm Water Pollution Prevention Plan (SWPPP) for the project in accordance with Arkansas Department of Environmental Quality (ADEQ) regulations. The Contractor shall be responsible for all fees, notices, notice of intent, notice of termination, disclosure statements, etc. associated with obtaining the Storm Water Permit. The Contractor shall submit all required forms and the SWPPP to the Engineer for Owner signature and forwarding to ADEQ.
- E. If the disturbed area is greater than 1 acre, the Contractor shall complete all required forms and prepare the Storm Water Pollution Prevention Plan and send to the Owner for signature and forwarding to ADEQ.
- F. If the disturbed area is less than 1 acre, the Notice of Coverage (NOC) and the SWPPP are not required. The Contractor shall prepare a drawing showing location and details of silt fences, barriers, etc. that the Contractor plans to install. The Contractor shall give the drawing to the Owner and Engineer for review. The Contractor shall follow Best Management Practices (BMP's) in accordance with ADEQ requirements.
- G. The Contractor shall be responsible for implementing the SWPPP (if a SWPPP is required by ADEQ), maintenance of the SWPPP, conducting inspections, implementing best management practices, site posting, and responsible for plan amendments. Contractor shall be responsible for the cost of all claims, losses, fines, penalties, or damages charged to Owner or Engineer due to Contractor's failure to comply with the requirements of the NPDES Storm Water Permit.
- H. Contractor shall, on Owner/Operator's behalf, execute all applicable requirements and discharge all duties as may be required for this project as described in ADEQ issued Construction General Permit titled "Authorization to Discharge Stormwater Under the National Pollutant Discharge Elimination system and the Arkansas Water and Air Pollution Control Act" including, but not limited to:
  - 1. Complete and post the NOC using forms acceptable to ADEQ;
  - 2. Timely preparation of the SWPPP, using a format acceptable to ADEQ;
  - 3. Ensuring that the site is in compliance with any changes or updates of the Permit;



4. Select, install, implement, and maintain best management practices at the construction site that minimize pollutants in stormwater discharges so as to meet applicable water quality standards;
5. Provide qualified personnel to conduct inspections and prepare inspection reports;
6. Maintain a file on site containing documents required by the SWPPP;
7. Achieve final stabilization;
8. Prepare and submit the NOT;
9. Execute other requirements as may be required by ADEQ and the Permit.
10. The Contractor shall be responsible for all fees, notices, notice of intent, notice of termination, disclosure statements, etc. associated with obtaining the Storm Water Permit.

- I. The Contractor shall not begin construction before the Notice of Coverage (NOC) and SWPPP is posted at the construction site. According to current ADEQ regulations, if the disturbed area is less than 1 acre the NOC and SWPPP are not required. If the disturbed area will be less than one acre, the Contractor shall submit a letter to the Owner stating such. The Contractor shall be required to use Best Management Practices if the disturbed area is less than one acre.

## 1.2 SECTION INCLUDES

- A. Temporary measures required to control erosion and sediment during construction. This includes measures to meet the requirements of the NPDES administered by the Environmental Protection Agency and the Arkansas Department of Environmental Quality.
- B. Stabilized construction entrance.
- C. Silt fence.
- D. Rock Check/Sand Bag Dams
- E. Storm Water Pollution Prevention Plan (SWPPP).

## 1.3 REFERENCES

- A. ASTM D751--Coated Fences.
- B. ASTM D3786--Hydraulic Bursting Strength of Knitted Goods and Non-woven Fabrics.
- C. ASTM A116--Zinc Coated (Galvanized) Steel Woven Wire Fence Fabric.
- D. ASTM D698--Test for Moisture Density Relations for Soils (Standard).

## 1.4 SUBMITTALS

- A. Submit in accordance with Section 01330 - Submittals.
- B. Submit the SWPPP.
- C. Product Data:
  1. Silt fencing.
  2. Non-woven filter fabric



D. Inspection Reports and Certificates:

1. Submit periodic inspection reports and certificates required for SWPPP.
2. Submit Contractor/Subcontractor certifications required for SWPPP.

E. Submit revisions or modifications to the erosion and sediment control plan and SWPPP.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. **Hay bales shall not be used for check dams.** Hay may be used for temporary stabilization of areas when spread. Hay bales shall be free of seeds.
- B. Stone material shall consist of rip-rap conforming to Arkansas Department of Transportation Standard Specifications and shall be placed as shown or in a layer of at least 12 inches thick.
- C. Geotextile Fabrics shall be a non-woven polypropylene fabric designed specifically for use as a soil filtration media. Fabric shall have an approximate weight of 6 oz/yd<sup>2</sup>, and shall conform to the following:

<u>Designation</u>	<u>Topic</u>	<u>Value</u>
ASTM D4632	Grab Strength (lbs.)	200
ASTM D4632	Grab Elongation	15%
ASTM D4533	Trapezoidal Tear (lbs.)	50
ASTM D751	Burst (psi)	320
ASTM D751	Puncture (psi)	80

ASTM D4751 Equivalent Opening Size (EOS) (mm)-soil retention.

For Soils in Which:

50% or less passes a #200 mesh sieve  
More than 50% passes a #200 mesh sieve

EOS:

Greater than a #30 sieve  
Greater than a #50 sieve

ASTM D4491 Permeability (k):

For Soils in Which:

Critical/Severe:  
Normal Applications:

EOS:

k (fabric) >10k (soil)  
k (fabric) >k (soil)

- D. Geotextile Silt Fence Fabric shall be a nylon reinforced polypropylene fabric having a reinforcing cord running the entire length to the top edge of the fabric. The fabric must meet or exceed the following criteria:

<u>Test Designation</u>	<u>Topic</u>	<u>Average Roll Minimum Value</u>
ASTM D4632	Grab Strength (lbs.)	90 lbs. @ 12"/minute
ASTM D4632	Grab Elongation	15% @ 12"/minute
ASTM D4751	Equivalent Opening Size (EOS)	U.S. sieve No. 20
ASTM D4491	Permittivity	>.01 sec.-1
ASTM D4355	U.V Resistance (500 hours exposure)	70%

- E. Fence Posts for Silt Fence shall be steel "T" posts of sufficient length to support the silt fence system.



- F. Woven Wire Support for Silt Fence: W1.4, 4" x 4", zinc coated (galvanized) steel woven wire fabric conforming to ASTM A116.
- G. Corrugated Metal Pipe: 16 gauge helical wound galvanized corrugated metal pipe.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION AND PREPARATION**

- A. The Contractor shall be responsible for reading and being thoroughly familiar with the permit and the storm water pollution prevention plan (SWPPP).
- B. The Contractor shall follow all requirements of ADEQ Short Term Activity Authorizations and Corps of Engineers Permits.
- C. Locate and protect survey horizontal and vertical control.
- D. Contractor shall install silt fencing along the low side of clearing limits (minimum) and in other areas as necessary to prevent siltation of area streams, ditches, swales, and drainages.

### **3.2 MAINTENANCE**

- A. Maintain erosion control devices as necessary to comply with the NPDES Storm Water Permit and Pollution Prevention Plan. This includes any revisions or modifications to the SWPPP. Any work required for modifications, revisions and maintenance shall be the responsibility of the Contractor and shall not be a basis for additional compensation.
- B. Maintain existing erosion and sedimentation control systems located within the project site.
- C. Inspect and repair or replace components of all erosion and sedimentation control systems as specified for each type of system. Unless otherwise directed, maintain the erosion and sedimentation control systems until the project is accepted by the Owner. Remove erosion and sedimentation control systems promptly when directed by the Owner. Discard removed materials off site.
- D. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction. Damages caused by construction traffic to erosion and sedimentation control systems shall be repaired immediately.
- E. Remove and dispose of sediment deposits. Offsite disposal will be the responsibility of the Contractor. Sediment to be placed at the project site shall be spread, compacted and stabilized in accordance with the Owner's directions. Sediment shall not be allowed to flush into stream or drainage way. If sediment has been contaminated, it shall be disposed of in accordance with existing federal, state and local regulations.





- F. Unless otherwise indicated, compact embankments, excavations, and trenches to mechanically blading, tamping, and rolling soil in maximum 8-inch lifts. Compaction density shall be at a minimum of 90 percent Standard Proctor ASTM D-698 density. Protect embankments from erosion by grassing or other Owner approved methods.

### 3.3 TEMPORARY HAY BALE DIKE

- A. Temporary hay bale dikes shall not be used.
- B. Hay may be used for temporary stabilization of areas if spread.

### 3.4 CONSTRUCTION ENTRANCE

- A. When necessary, wheels must be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone (Type "A" rip-rap) which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch or watercourse using approved methods.

### 3.5 SILT FENCE

- A. Silt fences shall be constructed as needed and as required by the NPDES permit to prevent siltation of area streams, ditches, swales, and drainages.
- B. Silt fence shall consist of nylon reinforced polypropylene netting supported by woven wire mesh, W1.4 x W1.4 and galvanized steel posts set a minimum depth of 2 feet and spaced not more than 6 feet on center. A 6-inch wide trench is to be cut 8 inches deep at the toe of the fence on the uphill side to allow the fabric to be laid below the surface and backfilled. Fabric shall overlap at abutting ends a minimum of 3 feet, and shall be joined such that no leakage or bypass occurs. Remove accumulated sediment when the depth reaches 6 inches.

### 3.6 ROCK CHECK/ SAND BAG CHECK DAM

- A. Rock Check/Sand Bag Dams shall be constructed as needed and as required by the NPDES permit to reduce velocity in channels. Geotextile fabric shall be placed beneath the rock and shall conform to these specifications.

### 3.7 SEDIMENT BASIN WITH STONE AND PIPE OUTLET

- A. Provide sediment basins as needed and as required by the NPDES permit at locations as needed by Contractor's construction sequence and operations.
- B. Install stone and pipe outlets for sediment basin at location shown and/or located as needed by Contractor's construction sequence and as required by the NPDES permit.
- C. Inspect sediment basin after each rainfall, daily during periods of prolonged rainfall, and a minimum of once a week. Maintain basin dimensions necessary to obtain the needed basin volume. Repair and replace damaged components of the basin.



## DIVERSION DIKE

- A. Diversion dikes shall be installed prior to and maintained for the duration of construction and shall intercept no more than five (5) acres of runoff. Dikes shall have a minimum top width of 2 feet and a minimum height of compacted fill of 18" measured from the top of the existing ground at the up-slope toe to top of the dike and having side slopes of 3:1 or flatter. The channel which is formed by the dike must have a minimum slope of one (1) percent for the entire length to an outlet. When the slope exceeds three (3) percent, or velocities exceed one foot per second (regardless of slope), stone stabilization is required. Plant grass on dikes not requiring stone stabilization.

END OF SECTION



## SECTION 02050

### SOILS AND AGGREGATES FOR EARTHWORK

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Aggregate base course.
  - 2. Granular fill.
  - 3. Native material.
  - 4. Sand.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. C117 - Standard Test Method for Materials Finer than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing.
  - 2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
  - 3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
  - 4. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
  - 5. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
  - 6. D4829 - Standard Test Method for Expansion Index of Soils.
  - 7. Arkansas Department of Transportation Manual of Standard Specification for Highway Construction

##### 1.03 SUBMITTALS

- A. Product data:
  - 1. Material source.
  - 2. Gradation.
  - 3. Testing data.
- B. Quality control for aggregate base course:
  - 1. Test reports: Reports for tests required by Sections of Arkansas Department of Transportation Standard Specifications.
  - 2. Certificates of Compliance: Certificates as required by Sections of Arkansas Department of Transportation Standard Specifications.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.



## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. General:
  - 1. Provide material having maximum particle size not exceeding 2 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.
  - 2. Materials derived from processing demolished or removed asphalt concrete are not acceptable.
- B. Aggregate base course:
  - 1. ARDOT Standard Specification for Highway Construction 303 Aggregate Base Course Class 7.
- C. Granular fill material:
  - 1. Consists of clean, sound earthen material for which the plasticity index when tested in accordance with ASTM D4318 shall be between 7 to 15.
  - 2. The organic content shall not be greater than 2 percent by volume.
  - 3. Liquid limits shall be less than 35 percent by volume.
  - 4. Conform to size and grade when tested in accordance with ASTM C117 and ASTM C136 as follows:
    - a. 100 percent passing the 2-inch sieve.
    - b. 100 – 70 percent passing the 3/4-inch sieve.
    - c. 25 – 15 percent passing the No. 4 sieve.
    - d. 10 – 0 percent passing the No. 200 sieve.
- D. Native material:
  - 1. Sound, earthen material passing 1-inch sieve.
  - 2. Percent of material by weight passing Number 200 sieve shall not exceed 30 when tested in accordance with ASTM C136.
  - 3. Expansion index less than 35 when tested in accordance with ASTM D4829.
- E. Sand:
  - 1. Clean, coarse, natural sand.
  - 2. Non-plastic when tested in accordance with ASTM D4318.
  - 3. 100 percent shall pass a 1/2-inch screen.
  - 4. No more than 20 percent shall pass a Number 200 sieve.

## **PART 3 EXECUTION**

Not Used.

END OF SECTION



## **SECTION 02200**

### **SITE CLEARING**

#### **PART 4 GENERAL**

##### **4.01 SUMMARY**

- A. Section includes: Clearing, grubbing, and stripping project site.

##### **4.02 REFERENCES**

##### **4.03 DEFINITIONS**

- A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.
- B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.
- C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the Engineer.

##### **4.04 QUALITY ASSURANCE**

- A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.
- B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

##### **4.05 PROJECT CONDITIONS**

- A. Environmental requirements:
  - 1. For suspected hazardous materials found: As specified in Section 01354 - Hazardous Material Procedures.

##### **4.06 SEQUENCING AND SCHEDULING**

- A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.



## **PART 5 PRODUCTS**

Not Used.

## **PART 6 EXECUTION**

### **6.01 EXAMINATION**

- A. Verification of conditions: Examine site and verify existing conditions for beginning work.

### **6.02 PREPARATION**

- A. Protect existing improvements from damage by site preparation work.

### **6.03 INSTALLATION**

- A. Clearing:
  - 1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
  - 2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
  - 3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.
- B. Grubbing:
  - 1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
  - 2. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.
- C. Stripping:
  - 1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
  - 2. Replace topsoil in areas disturbed during construction.

END OF SECTION



## SECTION 02240

### DEWATERING

#### PART 7 GENERAL

##### 7.01 SUMMARY

- A. Section includes:
  - 1. Installation and maintenance of dewatering systems.
  - 2. Disposal of water entering excavation or other parts of the work.

##### 7.02 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
  - 2. Dewatering design analysis. Include the following:
    - a. Evaluation of anticipated subsurface conditions.
    - b. Required well spacing.
    - c. Diameter of wells.
    - d. Depth to screen, screen height, and mesh size.
    - e. Backfill and filter pack.
    - f. Pump size.
    - g. Drawdown duration.
    - h. Drawdown and steady state flow rates.
    - i. Plans for de-silting of groundwater before discharge.
    - j. Expected settlements.
  - 3. Include water drawdown curves in dewatering calculations.
  - 4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.
  - 5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
  - 6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to finished grade.
  - 7. Provide standby power to ensure continuous dewatering in case of power failure.
- B. Dewatering shored excavations:
  - 1. Dewater from within shoring.
  - 2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
  - 3. Extend impermeable shoring below bottom of excavation sufficient amount to:
    - a. Minimize lowering of groundwater outside shoring.
    - b. Prevent unstable excavation due to piping and heave.





4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.
  5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.
- C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.
- D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.
- E. Discharge:
1. Discharge to storm drain manholes or storm drain inlets will be permitted.

### 7.03 SUBMITTALS

- A. Dewatering plan:
1. Dewatering design analysis.
  2. Required permits.
  3. Arrangement, location, and depths of dewatering system components.
  4. Type and sizes of filters.
  5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location. For pipes discharging to manholes, provide details of pipe entry at manhole.
- B. Well construction logs. Include:
1. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
  2. Construction details.
  3. Well development procedures and results.
  4. Deviations from original design.
- C. Qualifications:
1. Dewatering contractor.
  2. Dewatering design engineer.
  3. Testing laboratory.

### 7.04 QUALITY ASSURANCE

- A. Dewatering plan and dewatering system analysis:
1. Prepared by a qualified Civil Engineer, licensed in the state where the Project is located.
    - a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.
- B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.
- C. Testing laboratory shall meet discharge permit testing laboratory qualifications.
- D. Regulatory requirements:
1. Obtain required water discharge permits.



## **PART 8 PRODUCTS**

Not Used.

## **PART 9 EXECUTION**

### **9.01 INSTALLATION**

- A. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.
- B. Keep excavations reasonably free of water.
- C. Make provisions to maintain continuous dewatering:
  - 1. Provide standby power to maintain dewatering during power outages and interruptions.
  - 2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.
- D. Intercept and divert precipitation and surface water away from excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.
- E. Disposal of water:
  - 1. Dispose of water from the work in suitable manner without damage to adjacent property.
  - 2. Do not drain water into work built or under construction.
  - 3. Dispose of water in such manner that it will not be a menace to public health or safety.
- F. Wells, well points, and drain lines for dewatering:
  - 1. Provide after receiving Engineer's written acceptance.
  - 2. Fill dewatering wells, pipes, and french drains to be left in place within structure foundation limits with Class "C" concrete as specified in Section 03300 - Cast-in-Place Concrete or grout as specified in Section 03600 - Grouting.

### **9.02 CONSTRUCTION**

- A. Prior to release of groundwater to its static level: Confirm that:
  - 1. All groundwater pressure relief devices for structure are fully operational.
  - 2. Construction of structure is complete and concrete has reached its specified compressive strength.
  - 3. Backfill of structure is complete.
- B. Control release of groundwater to its static level to prevent disturbance of natural foundation soils or compacted backfills and fills and to prevent flotation or movement of structures, pipelines, or other facilities.

END OF SECTION



## SECTION 02260

### EXCAVATION SUPPORT AND PROTECTION

#### PART 10 GENERAL

##### 10.01 SUMMARY

- A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

##### 10.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
  - 1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

##### 10.03 DEFINITIONS

- A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
- B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.
- C. Support levels: Level of tiebacks, wales, rackers, bottom of excavation, and other types of support.

##### 10.04 SYSTEM DESCRIPTION

- A. Where General Engineering Design Practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
  - 1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
  - 2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.
- B. Design requirements:
  - 1. General:
    - a. For trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in.
      - 1) Perform design pursuant to general engineering design practice.
    - b. Dewatering:
      - 1) Dewater soil inside shoring as specified in Section 02240 - Dewatering for Structures.
      - 2) Do not lower groundwater outside of shoring more than 1 foot.



- 3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
  - c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
  - d. Minimum safety factor used for design shall not be less than 1.5.
  - e. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
  - f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
  - g. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
  - h. Generally acceptable references for design of shoring and excavations are as follows:
    - 1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
    - 2) Caltrans California Trenching and Shoring Manual.
    - 3) NAVFAC Design Manual 7.2.
    - 4) NAVFAC Design Manual 7.3.
    - 5) USS Steel Sheet Piling Design Manual.
2. Soldier piles and lagging:
- a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
  - b. Provide full face lagging all around penetrations through lagging.
  - c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 02312 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
  - d. Assumed effective width for passive soil resistance:
    - 1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
    - 2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
    - 3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
  - e. Fill voids behind lagging with gravel or other material acceptable to Engineer.
  - f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
    - 1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
    - 2) Do not eccentrically load structural section of soldier piles or wales.
  - g. Design soldier piles for downward loads including vertical loads from tieback anchors.
3. Soil anchors, rock anchors, and deadman anchors:
- a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
  - b. Proof load all production anchors to 125 percent of calculated load from shoring.



- c. Lock off production anchors at calculated load from shoring.
    - d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
    - e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
    - f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.
  - 4. Set inside face of shoring back from structure not less than greater of following:
    - a. 5 feet from face of wall.
    - b. 2 foot 6 inches from edge of foundation.
    - c. Depth of excavation below bottom of foundation.
- C. Performance requirements:
- 1. General:
    - a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
    - b. Specified provisions:
      - 1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
      - 2) Represent minimum requirement for:
        - a) Number and types of means needed to maintain soil stability.
        - b) Strength of such required means.
        - c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
  - 2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
  - 3. Provide support for trench excavations for protection of workers from hazard of caving ground.
  - 4. Provide shoring:
    - a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
      - 1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
      - 2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
    - b. For trenches 5 feet and deeper.
    - c. For trenches less than 5 feet in depth, when there is potential for cave-in.
    - d. Where indicated on the Drawings.
  - 5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:



- a. Using stiff shoring systems.
- b. Following appropriate construction sequence.
- c. Using shoring system that is tight enough to prevent soil loss through the shoring.
- d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
- e. Design for safety factor of not less than 1.50.
- f. Providing surface runoff routing and discharge away from excavations.
- g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
- h. Where sheet piling is used, use interlocking type sheets:
  - 1) Sheet piles shall be continuous and driven in interlock.
  - 2) If bottom of the excavation is located below the water table, use "ball and socket" or "thumb and finger" type interlock.
- i. Not applying shoring loads to existing structures and other improvements.
- j. Not changing existing soil loading on existing structures and other improvements.
- k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds **1/2** inch before wales are loaded.

#### 10.05 SUBMITTALS

- A. Shop drawings and calculations:
  - 1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
  - 2. Sketches showing the condition at various stages of installation and removal of shoring.
  - 3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
  - 4. When utilities penetrate shoring, show location of penetrations on elevation of all sides of shoring.
  - 5. Show details for ground support and sealing around utility penetrations.
  - 6. Indicate method used for installing driven shoring.
- B. Control points and schedule of measurements:
  - 1. Submit location and details of control points and method and schedule of measurements.
  - 2. Survey data.
- C. Detailed sequence of installation and removal of shoring:
  - 1. Consider effects of ground settlement in sequence of installation and removal of shoring.
  - 2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.
- D. Submit submittals for excavation support and protection as complete package and include all items required in this Section:
  - 1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.



- E. Submit dewatering submittals as specified in Section 02240 - Dewatering for Structures with submittals for excavation support and protection.

#### **10.06 SEQUENCING**

- A. Do not begin construction of any shoring or excavation operations until:
  - 1. Submittals for shoring and dewatering have been accepted.
  - 2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
  - 3. Materials necessary for installation are on site.
- B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

#### **PART 11 PRODUCTS**

Not Used.

#### **PART 12 EXECUTION**

##### **12.01 CONSTRUCTION**

- A. Installation of shoring:
  - 1. Install means for providing safe and stable excavations as indicated in submittals.
- B. Removal of shoring:
  - 1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of Work.
  - 2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
  - 3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
    - a. Inject grout starting at bottom of void and progressively fill void to grade.
    - b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
  - 4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.
- C. Control points:
  - 1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
    - a. Set control points on shoring support system:
      - 1) Set points at distances not exceeding 25 feet at each support level.
  - 2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.





3. Perform horizontal and vertical survey and measurement of control points at least once every week:
    - a. Field notes shall show current measurement and change in measurement from first measurement taken.
  4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
- D. Maintenance:
1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
  2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

## SECTION 02300

### EARTHWORK

## PART 13 GENERAL

### 13.01 SUMMARY

- A. Section includes:
1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
  2. Backfilling and compacting under and around structures.

### 13.02 REFERENCES

- A. ASTM International (ASTM):
1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN m/m<sup>3</sup>)).
  3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

### 13.03 DEFINITIONS

- A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
- B. Embankments: Dikes, levees, berms, and similar facilities.
- C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for



purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

#### **13.04 SYSTEM DESCRIPTION**

- A. Performance requirements:
  - 1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
  - 2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
  - 3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

#### **13.05 SUBMITTALS**

- A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.
- B. Excavation plan.
- C. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.
- D. Test reports:
  - 1. Submit certified test reports of all tests specified to be performed by the Contractor.
  - 2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering registered in the state where the project is located.

#### **13.06 QUALITY ASSURANCE**

- A. Initial compaction demonstration:
  - 1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
    - a. 50 cubic yards of backfill adjacent to structures.
    - b. 100 cubic yards of embankment work.
    - c. 100 cubic yards of fill.
    - d. 50 cubic yards of roadway base material.
    - e. 100 cubic yards of road fill.
  - 2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
  - 3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."
- B. Contractor shall perform all work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP) and as specified in Section 01355A – Stormwater Pollution Prevention Construction Activities: Best Management Practices.



### 13.07 SEQUENCING AND SCHEDULING

- A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.
- B. If necessary, stockpile excavated material in order to use it at specified locations.
- C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

## PART 14 PRODUCTS

### 14.01 MATERIALS

- A. Water for compacting: Use water from source acceptable to Engineer.
- B. Soil and rock materials:
  - 1. General:
    - a. Provide aggregate base course, controlled low-strength material, granular fill material native material, and sand where specified or indicated on the Drawings.
    - b. If suitable surplus materials are available, obtain native material from cut sections or excavations.
  - 2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 3. Granular fill material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 4. Native material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 5. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Materials (CLSM).
- D. Geotextile fabrics:
  - 1. Stabilization fabric: As specified in Section 02620 – Stabilization Fabric.
  - 2. Stabilization fabric shall be used under backfill at concrete structures and pavement, under aggregate base course at paved areas, and under aggregate base course at gravel surfaced areas.

## PART 15 EXECUTION

### 15.01 EXAMINATION

- A. Verification of conditions:
  - 1. Character and quantity of material:
    - a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
    - b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.



- c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
- d. Include wasting of excess material, if required, in cost of work to be performed.

## 15.02 PREPARATION

- A. Backfills:
  1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  2. Recompact scarified areas to density specified before placing backfill material or concrete.
  3. Do not place backfill against walls until:
    - a. Walls have been cast full height of structure and concrete has reached the specified strength.
    - b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
  4. Prior to backfilling:
    - a. Remove all forms.
    - b. Clean all trash and debris from the excavation site.
  5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.
- B. Fills:
  1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.
- C. Roadway fills:
  1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.

## 15.03 INSTALLATION

- A. General:
  1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
  2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.



3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
  4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.
- B. Borrow area: There is no borrow area on Project site.
1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.
  2. There will be no additional cost to the Owner for use of imported material.
- C. Compaction:
1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
  2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
  3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1557, or with ASTM D6938.
  4. Maximum density obtained in laboratory when tested in accordance with ASTM D1557.
  5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
  6. Compact to percentage of maximum density as follows:
    - a. Backfill adjacent to structures: 95 percent.
    - b. Backfilling voids: 95 percent.
    - c. Other areas: 85 percent.
    - d. Under present and future structures: 95 percent.
    - e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
    - f. Upper 6 inches of cuts: 95 percent.
    - g. Fills: 95 percent.
- D. Dewatering: As specified in Section 02240 - Dewatering.
- E. Excavation:
1. Blasting: Not permitted.
  2. Excavations for structures:
    - a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure, including trenching for piping and all work incidental thereto.
    - b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
    - c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.



- d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
    - 1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
    - 2) Under footings: Restore to the proper elevation using one of the following:
      - a) Aggregate base course.
  - e. Excavation width:
    - 1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
    - 2) Do not undercut slopes.
  - f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
  - 3. Necessary over excavation:
    - a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
    - b. Backfill voids with material acceptable to the Engineer:
      - 1) With acceptance of the Engineer, backfill with one of the following:
        - a) Aggregate base course.
        - b) Controlled low-strength material.
- F. Materials for backfills, embankments, fills, and roadway fills:
- 1. General:
    - a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
  - 2. Backfills:
    - a. Backfill adjacent to structures, slabs, or walls: Native material Granular fill material or imported material meeting the requirements of native material granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
    - c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  - 3. Fills:
    - a. Native material Granular fill material or imported material meeting the requirements of native material Granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  - 4. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
    - a. Aggregate base course material.

G. Placement:



1. General:
  - a. Lines and grades:
    - 1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
    - 2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
2. Backfills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted backfills: Remove and recompact.
3. Fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted fills: Remove and recompact.
4. Roadway fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted roadway fills: Remove and recompact.

#### 15.04 FIELD QUALITY CONTROL

- A. Tests:
  1. Confirmation tests:
    - a. Contractor's responsibilities:
      - 1) Accomplish specified compaction for backfills, fills, and other earthwork.
      - 2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
      - 3) Cost of confirmation tests: Paid for by the Contractor.
      - 4) Qualifications of Contractor's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the Engineer.
      - 5) Copies of confirmation test reports: Submit promptly to the Engineer.
    - b. Frequency of confirmation testing:
      - 1) Perform testing not less than the following:
        - a) In-place density:
          - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
          - (2) Cuts: 20 cubic yards.
          - (3) Fills: 20 cubic yards.
          - (4) Roadway fills: 20 cubic yards.
        - b) Maximum dry density versus moisture:
          - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
          - (2) Cuts: 20 cubic yards.
          - (3) Fills: 20 cubic yards.





- (4) Roadway fills: 20 cubic yards.
- 2. Compliance tests:
  - a. Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
  - b. Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
  - c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
    - 1) Remove and replace materials at proper density.
    - 2) Bring density up to specified level by other means acceptable to the Engineer.
  - d. Retesting:
    - 1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
    - 2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.
- B. Tolerances:
  - 1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
    - a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
    - b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
  - 2. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
    - a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
    - b. Intent of proceeding is to avoid sandy or gravelly areas.
  - 3. Finish grading of surfaces:
    - a. Reasonably smooth, compacted, and free from irregular surface changes.
    - b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
    - c. Uniformly grade areas that are not under concrete.
    - d. Finish ditches and gutters so that they drain readily.

#### 15.05 ADJUSTING

- A. Finish grades of excavations, backfills, and fills:
  - 1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

#### 15.06 PROTECTION

- A. Finish grades of backfills, cuts, excavations, and fills:
  - 1. Protect newly graded areas from erosion and deterioration by action of the elements.
- B. Ditches and gutters:



1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

## SECTION 02312

### CONTROLLED LOW STRENGTH MATERIAL (CLSM)

#### PART 16 GENERAL

##### 16.01 SUMMARY

- A. Section includes: Controlled low strength material (CLSM), also known as "flowable fill."

##### 16.02 REFERENCES

- A. American Concrete Institute (ACI):
  1. 229R - Report on Controlled Low-Strength Materials.
  2. 301 - Specifications for Structural Concrete.
- B. ASTM International (ASTM):
  1. C94 - Standard Specification for Ready Mix Concrete.
  2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
  3. C150 - Standard Specification for Portland Cement.
  4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
  5. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
  6. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  7. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
  8. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
  9. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

##### 16.03 SYSTEM DESCRIPTION

- A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.
- B. Performance requirements:
  1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.



2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
3. Wet density: Not greater than 132 pounds per cubic foot.
4. Slump, measured in accordance with ASTM C143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.

#### **16.04 SUBMITTALS**

- A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
  1. Cement: Mill tests. Indicate alkali content representative of each shipment.
  2. Fly ash: Identify source and type of fly ash.
  3. Water: Identify source and quality if not from a municipal treatment source.
  4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.
  5. Aggregate:
    - a. Submit source, type, and sieve analyses.
    - b. Resubmit at any time there is a significant change in grading of materials.
- B. Mix design:
  1. Submit full details, including mix design calculations for mix proposed for use.
  2. Trial batch test data:
    - a. Submit data for each test cylinder.
    - b. Submit data that identifies mix and slump for each test cylinder.

#### **16.05 DELIVERY, STORAGE AND HANDLING**

- A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.
- B. Store admixtures in accordance with the manufacturer's recommendations.

### **PART 17 PRODUCTS**

#### **17.01 MATERIALS**

- A. Cement:
  1. Portland cement in accordance with ASTM C150 Type I or Type II.
  2. Having total alkali content not more than 0.60 percent.
- B. Fly ash: Class C or Class F fly ash in accordance with ASTM C618.
- C. Water:
  1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
- D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM.
  1. Air entraining admixture: In accordance with ASTM C260.



## 17.02 MIXES

- A. See System Description for performance requirements of the plastic and hardened mix.

## 17.03 SOURCE QUALITY CONTROL

- A. Trial batch:
  - 1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
  - 2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
  - 3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in the this Section.
- B. Trial batch testing:
  - 1. Determine slump in accordance with ASTM C143, with the following modifications:
    - a. Do not rod the concrete material.
    - b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
  - 2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
    - a. Provide cylindrical test specimens, each 6-inches in diameter by 12-inch high.
    - b. Provide a minimum of 8 cylinders for testing of each trial batch.
    - c. Fill the molds to overflowing and tap sides lightly to settle the mix.
    - d. Do not rod the mix for consolidation in the cylinder.
    - e. Strike off the excess material.
  - 3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
  - 4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested.
    - a. Perform the capping carefully to prevent premature fractures.
    - b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
  - 5. Provide compressive strength tests:
    - a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
    - b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
- C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced.
  - 1. All the trial batches and acceptability of materials shall be paid by the Contractor.
  - 2. After acceptance, do not change the mix design without submitting a new mix design, trial batches, and test information.



## **PART 18 EXECUTION**

### **18.01 PREPARATION**

- A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.
- B. Remove debris foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

### **18.02 INSTALLATION**

- A. Pipes and trenches.
  - 1. Install cellular concrete as indicated on the Drawings and specified.
  - 2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
  - 3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.
  - 4. Place CLSM at specified access points in the abandoned in-place pipe.
- B. Soil preparation:
  - 1. Prior to placement of CLSM, prepare underlying soils as follows:
    - a. Scarify surface to a depth of 8 inches.
    - b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D1557.
    - c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D1557.

### **18.03 MEASURING, BATCHING, MIXING AND TRANSPORTING**

- A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.
- B. Mix until there is uniform distribution of materials.
- C. Discharge mixer completely prior to recharging.
- D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

### **18.04 PLACING**

- A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.
- B. Maintain fluid properties of the mix during placement.
  - 1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
  - 2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
  - 3. Handle and place CLSM using methods that minimize segregation of the mix.



4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
  5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.
- C. Lifts:
1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
  2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.
- D. Water conditions:
1. Do not place CLSM in standing or flowing water.
  2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
  3. Do not submerge CLSM in water within 24 hours after placement.
- E. Manage CLSM bleed water.
1. Grade top surface of CLSM to drain away from the fill.
  2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

#### **18.05 CURING AND PROTECTION**

- A. Curing:
1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.
- B. Protect CLSM from:
1. Damage from the elements.
  2. Damage of any nature during surrounding construction operations.
  3. Freezing: Do not use salt, manure, or other chemicals to provide cold.

#### **18.06 FIELD QUALITY CONTROL**

- A. Provide quality control over the Work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan and as specified in this Section.
- B. General:
1. Engineer inspection and acceptance required prior to placement.
  2. Make provisions for and furnish all material for the test specimens, and provide manual assistance in preparing said specimens.

#### **18.07 FIELD QUALITY ASSURANCE**

- A. Provide quality control over the work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan.
- B. Field inspections:
1. Engineer shall provide on-site inspection for the Work of this Section.



2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
  3. Required inspections:
    - a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
  4. Record of inspections.
- C. Field sampling and testing:
1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
  2. Required tests:
    - a. Air content: Prepare sample and test in accordance with ASTM D6023
    - b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832.
      - 1) Prepare 6-inch diameter by 12-inch high specimens for testing.
        - a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
        - b) Prepare and test not less than 3 cylinders for each set.
        - c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
        - d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
      - 2) Place the cylinders in a safe location away from construction activities.
        - a) Protect cylinders from bumping and impact.
        - b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
        - c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.
      - 3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
        - a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
        - b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
      - 4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
      - 5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.
      - 6) Cap and test for compressive strength in accordance with ASTM D4832.
        - a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
        - b) Test 1 cylinder at 7 days and 2 at 28 days.
      - 7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.





#### 18.08 NON-CONFORMING WORK

- A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.
- B. Engineer may:
  - 1. Reject CLSM represented by those test specimens and require its removal and replacement.
  - 2. Require modification of the mix design to provide CLSM with the properties specified.
- C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION



## **SECTION 02318**

### **TRENCHING**

#### **PART 19 GENERAL**

##### **19.01 SUMMARY**

- A. Section includes: Trench excavation and trench backfill.

##### **19.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>).
  - 3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

##### **19.03 SUBMITTALS**

- A. As specified in Section 01330 - Submittal Procedures.
- B. Product data on soils and aggregates.
  - 1. Material source.
  - 2. Gradation.
  - 3. Test data to demonstrate compliance with this Section.
- C. Samples:
  - 1. Provide 50-pound sample of materials when requested by the Engineer.
- D. Confirmation testing:
  - 1. Certification of Contractor's testing laboratory.
  - 2. Record copy report for tests performed by Contractor's testing laboratory.

##### **19.04 DEFINITIONS**

- A. Backfill: Material placed in trench above the pipe embedment zone.
- B. Bedding: Material placed under, around, and over pipes or ducts in trenches.
- C. Center bedding: Material placed at the bottom of the trench directly under the center of the pipe to provide a malleable resting surface.
- D. Fine grading: Material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.



- E. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
- F. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
- G. Lift: A layer of soil or aggregate material, measured before compaction.
- A. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
- B. Maximum density, field compaction: Soil density and water content when tested in accordance with ASTM D1556.
- C. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
- D. Pipe embedment zone: Includes bedding, fine grading, center bedding, and haunch zone.
- E. Pipe foundation: Material placed at the bottom of trench to provide support.
- F. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.
- G. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

## **PART 20 PRODUCTS**

### **20.01 MATERIALS**

- A. As specified in Section 02050 - Soils and Aggregates for Earthwork.
- B. Class C concrete: As specified in Section 03300 - Cast-in-Place Concrete.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Material (CLSM).

## **PART 21 EXECUTION**

### **21.01 PREPARATION**

- A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.



## 21.02 DEWATERING

- A. As specified in Section 02240 - Dewatering.

## 21.03 TRENCH EXCAVATION

- A. Excavate bottom of trench to depth indicated on the Drawings.
- B. Areas of new fill or embankment:
1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
  2. Excavate through fill for pipe trench.
- C. Trench widths as specified in the following table:

Buried Pipe Or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

- D. Potable water pipe and appurtenances:
1. Lay in trenches separate from those used for sewers.
  2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.

## 21.04 TRENCH BACKFILL - GENERAL

- A. Trench area terminology and locations as indicated on the Drawings.
- B. Place material, except CLSM and concrete, in maximum 6 inch lifts, measured before compaction.
- C. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

## 21.05 PIPE FOUNDATION

- A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.
1. Prepare pipe foundation, with any unauthorized excess excavation below elevation indicated on the Drawings, at no additional cost to Owner.
- B. If bottom of trench excavation consists of soil:
1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.



2. Materials and placement:
  - a. Recompact scarified material to 95 percent of maximum density.
- C. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
  1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
  2. Materials:
    - a. CLSM.
    - b. Class C concrete.
- D. If bottom of trench excavation consists of unacceptable material:
  1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
  2. Material and placement:
    - a. Aggregate base course material compacted to 95 percent of maximum density.
      - 1) Maximum particle size for backfill material limited as specified in the following table:

Buried Pipe	Maximum Particle Size
Nominal Pipe Diameter: 6 inch to 8 inch	3/4 inch
Nominal Pipe Diameter: 10 inch to 16 inch	1 inch
Nominal Pipe Diameter: Greater than 18 inch	1 1/2 inches

#### 21.06 PIPE EMBEDMENT ZONE

- A. General:
  1. Pipe displacement:
    - a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
    - b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
  2. Depressions for joints or couplings:
    - a. Excavate holes in graded trench bottom.
    - b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
- B. Rigid pipe:
  1. Fine grading:
    - a. Compacted depth below bottom of pipe: 6 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
  2. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.



- C. Flexible pipe:
  - 1. Center bedding:
    - a. Compacted depth below bottom of pipe: 12 inch minimum.
    - b. Compacted width below bottom of pipe: 1/3 of pipe outer diameter.
    - c. Materials and placement:
      - 1) Sand bags.
      - 2) Uncompacted sand at uniform density, minimize compaction.
  - 2. Haunch zone:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.
  - 3. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.

## 21.07 BACKFILL

- A. Trenches:
  - 1. Materials and placement:
    - a. Native soil compacted to 95 percent maximum dry density.
    - b. Imported fill compacted to 95 percent maximum dry density.
    - c. Aggregate base course compacted to 95 percent maximum dry density.
    - d. CLSM.
- B. Trenches in rock:
  - 1. Backfill to top of rock.
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.
  - 2. Backfill from top of rock to grade, if applicable:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent of maximum density.
- C. Trenches below or within 10 feet of the outside perimeter of structures:
  - 1. Backfill within aggregate base course below structure.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- D. Trenches in roadways and paved areas:
  - 1. Backfill trench to underside of pavement.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- E. Trenches in areas outside the improved section of roadways or in open country:
  - 1. Backfill to finished grade.



2. Materials and placement:
  - a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.
- F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
  1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
    - a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
    - b. Materials and placement:
      - 1) CLSM, unless otherwise indicated on the Drawings.
  2. Backfill remainder of trench:
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.

#### **21.08 EXCESS MATERIAL**

- A. Remove excess excavated material from the Project site as specified in Section 02300 - Earthwork.

#### **21.09 FIELD QUALITY CONTROL**

- A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.
- B. Confirmation tests: As specified in Section 02300 - Earthwork.
  1. Minimum frequency of confirmation testing:
    - a. At each test location include tests for each type or class of backfill from bedding to finished grade.
    - b. For trenches: 1 location every 200 linear feet.
    - c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
    - d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
    - e. Crossing paved roads: 1 location at each crossing.
    - f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
- C. Compliance tests:
  1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
  2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
    - a. Remove and replace backfill at the proper density.
    - b. Other means acceptable to the Engineer.
  3. Retesting:
    - a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.



- b. Contractor's confirmation tests during performance of remedial work:
  - 1) Performance: Perform tests in manner acceptable to the Engineer.
  - 2) Frequency: Double amount specified for initial confirmation tests.
- D. Piping system testing:
  - 1. As specified in Section 15956 - Piping Systems Testing.

END OF SECTION





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## **SECTION 02600**

### **CONCRETE MANHOLES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Manhole frames and covers.
  - 2. Manhole grade rings.
  - 3. Manholes cones and risers.
  - 4. Manhole bases.

##### **1.02 REFERENCES**

- A. American Association of State Highway and Transportation Officials (AASHTO).
  - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
  - 1. A48 - Standard Specification for Gray Iron Castings.
  - 2. C33 - Standard Specification for Concrete Aggregates.
  - 3. C150 - Standard Specification for Portland Cement.
  - 4. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
  - 5. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
  - 6. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
  - 7. C923 - Standard Gide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.
  - 8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
- C. International Organization of Standardization (ISO):
  - 1. 9001 - Quality Management Standard.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings:
  - 1. Manufacturer's catalog data and details of following items for approval:
    - a. Frame and covers.
    - b. Grade rings.
    - c. Manhole cones and risers.
    - d. Manhole bases, if precast.
  - 2. Manhole construction details, jointing methods, connection details, materials, and dimensions.
  - 3. Repair procedures and details.



- C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.
- D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.
- E. Sealed drawings and design calculations by a registered Professional Engineer licensed in the State where the project is located.
- F. Certificates
  - 1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
  - 2. Manufacturer's Certificate of Source Testing.

#### **1.04 PRODUCT REQUIREMENTS**

- A. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
  - 1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
  - 2. Dragging or dropping the manhole components shall not be allowed.
- B. Source testing.
  - 1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
    - a. In lieu of this experience, witness of tests by up to 3 full-time Owner representatives.
  - 2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
  - 3. Complete required testing in accordance with ASTM C478.
  - 4. Provide the Manufacturer's Certificate of Source Testing.

#### **1.05 DESIGN CRITERIA:**

- A. Manholes shall not include steps.
- B. Manhole lids: Locking (watertight) type.
- C. Manhole bases:
  - 1. Constructed in accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
- D. Manhole riser:
  - 1. In accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
  - 2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.
- E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.



- F. Manhole systems:
  - 1. Provided by a single manufacturer.
- G. Frames and covers:
  - 1. Provided by a single manufacturer unless approved by the Engineer.

#### **1.06 WARRANTY**

- A. As specified in Section 01783 - Warranties and Bonds.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Manhole grade rings, cones, and risers: One of the following or equal.
  - 1. Peterson Concrete.
- B. Manhole frames and covers: Manufacturers: One of the following or equal.
  - 1. East Jordan Iron Works – Model V2418.
  - 2. Neenah Foundry Company.

#### **2.02 BASIS OF DESIGN**

- A. Design in accordance with local jurisdiction requirements and Little Rock Water Reclamation Authority Standard Details, including but not limited to the following:
  - 1. Manhole frames and covers.
  - 2. Manhole diameter tolerance.
  - 3. Manhole length.
  - 4. Manhole cover bolting.
  - 5. Manhole backfill.
- B. Structural design calculations:
  - 1. Load rating of manhole:
    - a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
  - 2. Resist buoyancy:
    - a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
    - b. Depths will be as indicated on the Drawings.
    - c. Refer to the geotechnical report for soil condition including fully saturated soil conditions.
- C. Manholes, grade rings, risers, and bases:
  - 1. Manhole:
    - a. Nominal sizes as indicated on the Drawings.
  - 2. Grade rings:
    - a. At least 1 but not more than 2 grade rings shall be used.
    - b. Maximum total distance from top of cone section to final grade: In accordance with Little Rock Water Reclamation Authority Standard Details.



3. Cone and riser sections:
    - a. As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
    - b. Cone sections shall be concentric.
  4. Manhole bases:

As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
- D. Threaded lifting inserts:
1. Design inserts to be fully threaded:
    - a. Do not fully penetrate through entire manhole wall.
  2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
  3. Design with minimum safety factor of 4.0.
  4. Do not use reinforcing steel bars.

## 2.03 MATERIALS

- A. Cast iron manhole frames and covers.
1. In accordance with ASTM A48 and Little Rock Water Reclamation Authority Standard Details.
  2. Covers: Bolted (Watertight) as specified.
  3. Concrete collars: As indicated on the Drawings.
- B. Manhole bases, risers, and grade rings:
1. Cement: Type II portland cement in accordance with ASTM C150.
  2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
  3. Sections: Steel reinforced.
  4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
  5. Top and bottom of sections: Parallel.
  6. In accordance with Little Rock Water Reclamation Authority Standard Details.
- C. Joint sealant:
1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
  2. Manufacturers: One of the following or equal.
    - a. Tylox Superseal.
    - b. Kent Seal - Hamilton Kent Corp.
- D. Exterior joint wrap:
1. Butyl based seal that is self-priming, self-sealing, and permanently flexible designed to create a high-performance seal in precast structures.
  2. Sealant shall provide a flexible watertight seal around perimeter of joint.
  3. Seal shall be highly resistant to temperature extremes and acid or caustic environments.
  4. Width = 6" minimum.
  5. Manufacturers: One of the following or equal.
    - a. Sealing Systems Inc. - Infi-Shield Gator Wrap.
    - b. Trelleborg – Bidco External Joint Wrap.



## 2.04 COMPONENTS

- A. Pipe stubs:
  - 1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
  - 2. Plugging stubs:
    - a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
    - b. Unless otherwise indicated on the Drawings, comply with following:
      - 1) Stubs up to and including 21 inches: Vitrified clay stoppers.
      - 2) Stubs greater than 21 inches: Brick plugs.
- B. Resilient pipe connectors:
  - 1. Unless otherwise indicated on the Drawings or specified, provide a flexible watertight compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
  - 2. Resilient pipe connectors:
    - a. Manufacturers: The following or equal.
      - 1) A-LOK Premium.
      - 2) NPC Kor-N-Seal.
- C. Threaded lifting inserts.
- D. Drop manholes:
  - 1. Construct drop manholes at locations and in accordance with details indicated on the Drawings in accordance with Little Rock Water Reclamation Authority Standard Details.
  - 2. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
  - 3. Furnish and set fittings as indicated on the Drawings.

## 2.05 IDENTIFICATION MARKINGS

- A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
  - 1. Date of manufacture of the item.
  - 2. Name or trademark of the manufacturer.
  - 3. Internal diameter in inches.
  - 4. Number of the manhole as indicated on the Drawings.

## 2.06 QUALITY CONTROL

- A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.
- B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the Owner or Owner's representative.
- C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
  - 1. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.



2. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe.
  - a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
  - b. Devices are subject to inspection by Engineer.
- D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.
- E. Remove rejected manholes immediately.

### **PART 3 EXECUTION**

#### **3.01 MANHOLE INSTALLATION**

- A. Excavate and backfill as specified in Section 02318 - Trenching and as indicated on the Drawings.
- B. Maintain identification markings on installed pieces throughout installation.
- C. Do not use sections with chips or cracks in the joint.
- D. Engineer may inspect manhole sections, prior to installation.
- E. Repair of manhole sections damaged during installation in accordance with manufacturer's repair procedures; with the concurrence of the Engineer.
- F. Install joint sealant material in accordance with manufacturer's instructions:
  1. Completed manhole: Rigid and watertight.
- G. Fill threaded lifting inserts with grout.
- H. Lay grade rings on joint sealant with sides plumb and tops level.
- I. Set frame and covers as specified and as indicated on the Drawings.
- J. Dampproofing is not required.

#### **3.02 CLEANING**

- A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.
- B. After completing each manhole, remove construction material debris from inside the manhole.

#### **3.03 FUNCTIONAL TESTING**

- A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.



- B. Vacuum testing in accordance with ASTM C1244.
1. Install the vacuum test head on top of the manhole.
    - a. Install and brace sealing devices on influent and effluent pipes.
  2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
  3. Compare test results with the minimum time requirements stated in the table below.
    - a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

<b><u>Minimum Elapsed Time, Minutes: Seconds</u></b>				
<b>Manhole Depth, ft.</b>	<b>Manhole Diameter, inches</b>			
	36	48	60	72
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:46	0:57
16	0:28	0:40	0:52	1:07
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:05	1:21
22	0:38	0:55	1:12	1:29
24	0:42	0:59	1:18	1:37
26	0:46	1:04	1:25	1:45
28	0:49	1:09	1:31	1:53
30	0:53	1:14	1:38	2:01

END OF SECTION



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## **SECTION 02621**

### **STABILIZATION FABRIC**

#### **PART 4 GENERAL**

##### **4.01 SUMMARY**

- A. Section includes: Woven stabilization fabric used for subgrade enhancement.

##### **4.02 REFERENCES**

- A. ASTM International (ASTM):
1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
  2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
  3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
  4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
  5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
  6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
  7. D4595 - Standard Test Method for Tensile Properties of Geotextiles by the wide strip method.

##### **4.03 DEFINITIONS**

- A. Stabilization fabric: Woven geotextile fabric manufactured from polypropylene yarns.

##### **4.04 SUBMITTALS**

- A. Product data.
- B. Samples.
- C. Quality control submittals:
1. Certificates of Compliance.
  2. Manufacturer's Installation Instructions.

##### **4.05 DELIVERY, STORAGE, AND HANDLING**

- A. Storage and protection:
1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.





#### 4.06 PROJECT CONDITIONS

- A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

### PART 5 PRODUCTS

#### 5.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 2x2HF.
  2. Ten Cate Geosynthetics, Mirafi HP270.

#### 5.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property <sup>(1)</sup>	Test Method	Unit	Requirements <sup>(1)</sup>
Grab Tensile Strength	ASTM D4595	lbs	2640
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	80
Apparent Opening Size (AOS)	ASTM D4751	US sieve	30
Permittivity	ASTM D4491	sec <sup>-1</sup>	0.06
Flow Rate	ASTM D4491	gpm/ft <sup>2</sup>	40
(1) Minimum average roll values.			

### PART 6 EXECUTION

#### 6.01 EXAMINATION

- A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

#### 6.02 PREPARATION

- A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

#### 6.03 INSTALLATION

- A. Follow manufacturer's installation instructions and as complimented in this Section.
- B. Place the stabilization fabric smoothly without folds or wrinkles.



- C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.
- E. Do not drag stabilization fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.
- G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

#### **6.04 FIELD QUALITY CONTROL**

- A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION



## **SECTION 02772**

### **CONCRETE CURBS, GUTTERS, AND SIDEWALKS**

#### **PART 22 GENERAL**

##### **22.01 SUMMARY**

- A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

##### **22.02 SYSTEM DESCRIPTION**

- A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

##### **22.03 SUBMITTALS**

- A. Product data: Submit data completely describing products.
- B. Samples: Submit samples when requested.

#### **PART 23 PRODUCTS**

##### **23.01 MATERIALS**

- A. Concrete: Class A, as specified in Section 03300 - Cast-In-Place Concrete.
- B. Curb finishing mortar: 1 part portland cement to 2 parts sand.
- C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.
- D. Joint materials:
  - 1. Expansion: As specified in Section 03150 - Concrete Accessories.

#### **PART 24 EXECUTION**

##### **24.01 EXAMINATION**

- A. Verification of Conditions:
  - 1. Verify field conditions, including subgrade condition and interferences, before beginning construction.



## 24.02 PREPARATION

- A. Surface preparation:
  - 1. Subgrade:
    - a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 02050 - Soils and Aggregates for Earthwork.
    - b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
  - 2. Forms and subgrade: Water immediately in advance of placing concrete.

## 24.03 INSTALLATION

- A. Special techniques:
  - 1. Contractor's option:
    - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
    - b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
    - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
    - d. Discontinue use of machines when results are not satisfactory to the Engineer.
- B. Forms:
  - 1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
  - 2. Thoroughly clean prior to each use and coat with form releasing material.
- C. Expansion and weakened-plane joints:
  - 1. Expansion joints:
    - a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
    - b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
    - c. Fill joints with expansion joint filler material.
  - 2. Weakened-plane joints:
    - a. Construct as indicated on the Drawings.
    - b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.
- D. Concrete:
  - 1. Placing:
    - a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
  - 2. Compacting:
    - a. Compact by mechanical vibrators accepted by the Engineer.
    - b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.



3. Form removal:
    - a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
    - b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
  4. Finishing and curing: Comply with requirements as specified in Section 03366 - Tooled Concrete Finishing except as modified here:
    - a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
    - b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
    - c. Edge concrete at expansion joints to 1/4 inch radius.
    - d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
    - e. Sidewalks and ramps: Broom finish
- E. Backfilling:
1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

#### **24.04 FIELD QUALITY CONTROL**

- A. Tests:
1. Curbs and gutters:
    - a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
    - b. Correct deviations in excess of 1/4 inch.
  2. Gutters:
    - a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
    - b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
    - c. Required results:
      - 1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
      - 2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

#### **24.05 ADJUSTING**

- A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.



- B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION

#### SECTION 02939

##### SEEDING

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#### PART 7 GENERAL

##### 7.01 SUMMARY

- A. Section includes seeding.



## 7.02 REFERENCES

- A. Association of Official Seed Analysts (AOSA).
- B. United States Department of Agriculture (USDA).
- C. United States Environment Protection Agency (EPA).

## 7.03 DEFINITIONS

- A. Duff layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B. Finish grade: Elevation of finished surface of planting soil.
- C. Manufactured topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F. Planting soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- H. Surface soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.
- I. Weeds:
  - 1. Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Russian Thistle, Leafy Spurge, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Weed, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

## 7.04 SUBMITTALS

- A. Product data: For each type of product indicated:
  - 1. Pesticides and herbicides: Include product label and manufacturer's application instructions specific to this Project.



2. Fertilizer and organic matter: Include product label and manufacturer's application instructions specific to this Project.
  3. Soil amendment: Analysis.
- B. Certification of grass seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
1. Certification and inspection as required by governmental authorities of each seed mixture. Include identification of source and name and telephone number of supplier.
- C. Qualification data: For qualified landscape Installer.
- D. Samples: Imported topsoil, organic matter, erosion control blanket and mulch.
- E. Product certificates: For soil amendments and fertilizers, from manufacturer.
- F. Maintenance instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

#### **7.05 QUALITY ASSURANCE**

- A. Installer qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
1. Professional membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
  2. Experience: 5 years' successful experience in the installation of seeded areas similar in size to this project.
  3. Installer's field supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  4. Personnel certifications: Installer's field supervisor shall have certification in all of the following categories from the Professional Landcare Network:
    - a. Certified Landscape Technician - Exterior, with installation and irrigation specialty area(s).
  5. Maintenance proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
  6. Pesticide applicator: State licensed, commercial.
- B. Soil-testing laboratory qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil. Refer to plan notes for number and location of soil analysis tests.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.





2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Engineer.
  - a. A minimum of 3 representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.
  - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated.
    - 1) State recommendations in weight per 1,000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
  - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Pre-installation conference: Conduct conference at project site.

#### **7.06 DELIVERY, STORAGE, AND HANDLING**

- A. Seed and other packaged materials:
  1. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
  2. Protect seed during delivery and storage.
  3. Seed that has become wet or otherwise damaged will not be acceptable.
- B. Deliver packaged materials in waterproof bags showing weight, chemical analysis and name or trademark of manufacturer.
  1. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, percentage of purity (PLS), percentage of germination and location of packaging.
- C. Local sourcing of seed not in sealed containers is permitted for smaller projects.
- D. Label seed bags per variety.
- E. Store materials in protected and covered storage until application or use.
- F. Bulk materials:
  1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.
- G. Truck receipts: For verification of all soil amendments and imported topsoil.
- H. Hydroseeding:
  1. Ensure that seed packages are packed to provide adequate protection against injury during transit.



2. Deliver undamaged sealed seed bags with legible labels showing weight, analysis, vendor's name and address, and point of origin.
  - a. Label seed bags per variety.
3. Deliver dry commercial process or packaging, such as fertilizer, in undisturbed original unopened containers with legible labels showing the manufacturer's guaranteed analysis or description.
4. Inspect materials and packages upon delivery.
  - a. Discard damaged packages or containers immediately.
5. Store materials in protected and covered storage until application or use.

#### **7.07 WARRANTY**

- A. Warranty:
  1. Guarantee all seeding to be alive and healthy for 1 years following date of final completion by the Engineer.
  2. Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
  3. All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
  4. The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
  5. Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
  6. Maximum single bare spot size of non-irrigated seed is 1 square foot.
  7. All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
- B. Replace seeding when it is no longer in a satisfactory condition or do not meet the preceding standard as determined by the Engineer or the duration of the Guarantee/Warranty Period.
  1. Make replacements as soon as possible within the recommended seeding schedule.
- C. Replacements:
  1. Seed of same mix, quality and species as originally specified, as soon as possible within the recommended seeding schedule, with a new 1-year warranty commencing on date of replacement.
  2. Repairs and replacements shall be made at no expense to the Owner.

### **PART 8 PRODUCTS**

#### **8.01 STAKES**

- A. Softwood lumber, chisel pointed.

#### **8.02 SOIL AMENDMENTS AND FERTILIZERS**

- A. Apply soil amendments and fertilizer as indicated on the Drawings.
- B. Submit soil amendment and fertilizer recommendations, along with supporting soil test analysis, for Engineer approval prior to application on the site.
- C. Fertilizer:



1. Uniform in composition, free flowing and suitable for application with approved equipment, of the proportions necessary to eliminate any deficiencies of topsoil, as indicated in analysis.
  2. Delivered to the site fully labeled according to applicable laws.
  3. Packaging: Display the name, tradename, trademark and warranty of the provider.
- D. Fertilizer grade description format:
1. Three sets of 2-digit numbers.
  2. Numbers represent the percent by weight of nutrients.
  3. First number is the amount of nitrogen (N).
  4. Second number is the amount of phosphate (P<sub>2</sub>O<sub>5</sub>).
  5. Third number is the amount of potash (K<sub>2</sub>O).
  6. Example: 10 10 10.

### **8.03 HERBICIDE AND PESTICIDE**

- A. Submit labels for Engineer approval.
- B. Pesticides:
1. Registered and approved by EPA.
  2. Acceptable to authorities having jurisdiction.
  3. Type recommended by manufacturer for each specific problem.
  4. As required for Project conditions and application.
  5. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- C. Pre-emergent herbicide (Selective and Non-Selective):
1. Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- D. Post-emergent herbicide (Selective and Non-Selective):
1. Effective for controlling weed growth that has already germinated.

### **8.04 WATER**

- A. Use potable water for making up seed mixture.
- B. Plant effluent may be used for hydroseeding watering and maintenance with Owner approval, as specified in this Section.

### **8.05 SOILS**

- A. Topsoil:
1. Fertile soil, typical for locality, capable of sustaining vigorous plant growth.
  2. Taken from drained site.
  3. Free of subsoil, stones more than 1 inch in diameter, clay clumps, or impurities, plants weeds and roots.
  4. Organic content:
    - a. Minimum 2 percent by mass.
  5. pH value:
    - a. Minimum: 5.5.
    - b. Maximum: 7.5.



## 8.06 SEED

- A. Provide seed as indicated on the Drawings.
- B. Packaging: Provide separate bags or containers for each variety of seed.
- C. Plant seed that is appropriate for planting season.
- D. Provide seed from tested lots and delivered to project site in standard containers labeled as required by U.S. Department of Agriculture regulations and applicable state regulations.
- E. Use labels that show variety of strain of seed, degree of purity (percent), rate of germination (percent), weed content (percent), and date of test.
- F. Lawn seed:
  - 1. Common name: Bermuda grass (*Cynodon Dactylon*).
  - 2. Planted from April 15 to July 15.
  - 3. Fancy hulled seed.
  - 4. Seed mixture:
    - a. Germination minimum: 88 percent.
    - b. Pure seed minimum: 94 percent.
    - c. Weed seed maximum: 0.35 percent.
- G. Grass seed:
  - 1. Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
  - 2. Species: Match existing grass type.
  - 3. Seed mixture:
    - a. Germination minimum: 95 percent.
    - b. Pure seed minimum: 85 percent.
    - c. Weed seed maximum: 0.5 percent.
    - d. Other than grass seed, non-viable seed, chaff, hulls, live seed of crop plants (other than those specified), harmless inert matter, and maximum: 18 percent.
  - 4. Proprietary seed mix: Western Native Seed near Salida, CO.
- H. Buffalo grass mix:
  - a. Common name: "Topgun" or "Texoka" seed.
  - b. Drill rate: 90 pounds of seed per acre (2 pounds 100 feet square).
  - c. Timing: April 1 - September 1.
  - d. Cannot be hydro-mulched.
    - 1) Areas susceptible to erosion: Cover drilled seeded area with hydro-mulched fiber.
- I. Wildflower seed:
  - 1. Wildflower seed mix from latest crop.
  - 2. Seed mixture:
    - a. Pure live seed content minimum: 80 percent.
  - 3. Seed testing maximum: 6 months from planting date.
    - a. Do not use seed mix after expiration date.
  - 4. Seeding rate:
    - a. *Lupinus luteus*: 8 pounds per acre.



- b. Eschscholtzia Californica: 1.9 pounds per acre.
- c. Gazania Splendeus: 12 pounds per acre.
- d. Clarkia Amoena: 4.5 pounds per acre.
- e. Lasthenia Glabrata: 4 pounds per acre.
- f. Achillea Borealis: 3 pounds per acre.
- g. Stipa Pulchrum: 3 pounds per acre.
- h. Gilia Capitata: 6 pounds per acre.
- i. Festuca Idahoeasis: 4 pounds per acre.

- J. Erosion control seed:
  - 1. Erosion control seed mix from latest crop.
  - 2. Seed mixture:
  - 3. Pure live seed content minimum: 80 percent.
  - 4. Seed testing maximum: 6 months from planting date.
    - a. Do not use seed mix after expiration date.
  - 5. Seeding rate:
    - a. Blando Brome: 20 pounds per acre.
    - b. Annual Rye: 25 pounds per acre.
    - c. Rose Clover: 20 pounds per acre.
    - d. Zorro Annual Fescue: 10 pounds per acre.

#### 8.07 MULCHES

- A. As indicated on the Drawings.
- B. Straw mulch:
  - 1. Oats, barley, wheat or rye only.
  - 2. Free from weeds, foreign matter detrimental to plant life, and dry.
  - 3. Minimum length 10 inches long: 50 percent of straw.
  - 4. Not acceptable:
    - a. Hay or chopped cornstalks.
    - b. Old straw mulch which breaks during crimping.
    - c. Straw in such an advanced stage of decomposition as to smother or retard the normal growth of grass.
- C. Wood cellulose fiber mulch:
  - 1. Wood fibers must be capable of being evenly dispersed and suspended when agitated in water.
  - 2. Furnish with a biodegradable green dye to allow visual metering of its application.
  - 3. Not acceptable:
    - a. Substance or factor which might inhibit germination or growth of grass seed, with organic tacifier.

#### 8.08 HYDRO-MULCH

- A. Hydro-mulch seed:
  - 1. Seeding:
    - a. Mixture:
      - 1) Ratio of wood cellulose fiber, seeds and fertilizer: 4:1:6 mixture.
        - a) Fiber: 20 pounds.
        - b) Seeds: 5 pounds.
      - (1) Modify mixture according to the planting season as follows:



- (a) February through August: 20 pounds of hulled common Bermuda grass per acre.
      - (b) August through February: combination of 15 pounds of unhulled common Bermuda and 15 pounds of unhulled Gulf Coast Annual Rye seed per acre.
      - c) Fertilizer: 30 pounds.
    - 2) Coverage: 1,000 square feet.
  - b. Provide a recommendation for proposed mixture based on time of year hydro-mulch is actually performed.
- B. Hydro-mulching equipment:
  - 1. Manufacturers: One of the following or equal:
    - a. Bowie Industries, Inc.
    - b. Reinco.
    - c. Finn Equipment Co.
  - 2. Equipment requirements:
    - a. Built-in agitation system sufficient to agitate, suspend, and homogeneously mix slurry containing fiber, fertilizers, chemicals, and seed mix.
    - b. Capable of slurry distribution line large enough to prevent stoppage.
    - c. Equipped with set of hydraulic spray nozzles which provide continuous non-fluctuating discharge of minimum 225 pounds per square inch at end of spray nozzle.

#### 8.09 HYDROSEEDING MATERIALS

- A. Seed mix:
  - 1. Manufacturers: One of the following or equal:
    - a. Grass Growers.
    - b. Conwed Corp.
    - c. Eva Cell Co.
  - 2. Seed mix from the latest crop.
  - 3. Minimum pure live seed content to be 80 percent, and tested within the preceding 6 months.
  - 4. Do not use seed mix after expiration date:
    - a. Blando Brome: 20 pounds per acre.
    - b. Annual Rye: 25 pounds per acre.
    - c. Rose Clover: 20 pounds per acre.
    - d. Zorro Annual Fescue: 10 pounds per acre.
- B. Mulch:
  - 1. Wood fiber manufactured for hydroseeding: Fiber mulch:
  - 2. Manufacturers: One of the following or equal:
    - a. Grass Growers.
    - b. Conwed Corp., Fibers Div.
    - c. Eva Cell Co.
- C. Water:
  - 1. Use potable water for making up seed mixture.
  - 2. Plant effluent may be used for hydroseed watering with Owner approval as specified in this Section.





- D. Granular fertilizers:
  - 1. Manufacturers: One of the following or equal:
    - a. Sierra Chemical Co.
    - b. Green Light Co., Wonder Grow Chemicals.
    - c. Kay-Fries Chemicals.
  - 2. Fertilizer grade: 16-20-0.

#### **8.10 EROSION CONTROL BLANKETS**

- A. As indicated on the Drawings.
- B. Erosion control blanket:
  - 1. Manufacturer: The following or equal:
    - a. American Excelsior Company, Curlex®.
  - 2. Jute matting, open weave.
  - 3. Regular blanket, machine produced mat of curled wood excelsior of 80 percent 6 inch or longer fiber length with a consistent width of fibers evenly distributed throughout mat.
  - 4. Photo-biodegradable extruded plastic netting cover the top side of blanket.
  - 5. Secure netting to wood excelsior by extra heavy lines of plastic woven into the width of each blanket.
  - 6. Smolder resistant with no chemical additives.

### **PART 9 EXECUTION**

#### **9.01 EXAMINATION**

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
  - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
  - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 4. Uniformly moisten excessively dry soil that is not workable, and which is too dusty.
- B. Start of work covered in this Section constitutes Contractor's approval of all existing site conditions.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by the Engineer and replace with new planting soil.



## 9.02 SITE CONDITIONS

- A. Planting restrictions: Plant during 1 of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date.
  - 1. Irrigated seed areas: Seed from ground thaw to July 31 and September 1 to October 15.
  - 2. Non-irrigated seed areas: Seed from March 15 to July 4 and September 1 to October 15.
  - 3. Pure Warm Season Grass Seed Areas: Seed from June 1 to August 15.
  - 4. Dormant Seeding Areas: Seed from October 15 to ground freeze.
  - 5. Per seed detail.
- B. Coordinate with Contractor's work requiring access to site over existing vegetation areas.
  - 1. No trucking or moving of equipment or materials shall be permitted over completed seed areas.
- C. Coordinate with installation of all underground system piping and outlets.
- D. Weather limitations:
  - 1. Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained.
  - 2. Apply products during favorable weather conditions according to manufacturer's written instructions.

## 9.03 EXISTING VEGETATION RENOVATION

- A. Renovate existing vegetation.
- B. Renovate existing vegetation damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  - 1. Reestablish vegetation where settlement or washouts occur or where minor regrading is required.
  - 2. Install topsoil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory vegetation areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing vegetation.
- F. Prior to seeding, irrigate for a minimum of 2 weeks to allow germination of weed seeds.
  - 1. Apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.
  - 2. Do not spray on a day when wind is detectable.
  - 3. Remove remaining vegetative matter.
  - 4. Repeat irrigation and herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.



- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil.
  - 1. Install new planting soil to fill low spots and meet finish grades.
- J. Apply seed and protect with hydro mulch as required for new vegetation.
- K. Water newly planted areas and keep moist until new turf is established.

#### **9.04 PREPARATION**

- A. Protect existing and new structures, fences, utilities, sidewalks, paving, curbs, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
  - 1. Protect adjacent and adjoining areas from hydromulching overspray.
  - 2. Protect grade stakes set by others until directed to remove them.
  - 3. Protect landscaping and other features remaining as final work.
- B. Limit turf subgrade preparation to areas to be planted.
- C. Newly graded subgrades:
  - 1. Loosen/scarify subgrade to a minimum depth of 6 inches.
  - 2. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
  - 3. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted the subgrade.
  - 4. Tolerances: Top of subgrade plus or minus 1 inch.
- D. Prepare subgrade and eliminate uneven areas and low spots.
  - 1. Maintain lines, levels, profiles and contours.
  - 2. Make changes in grade gradual. Blend slopes into level areas.
- E. Do not prepare subgrade in areas of on-site plant preservation.
- F. Do not bury foreign material beneath areas to be seeded.
- G. Remove any contaminated subgrade.
  - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
    - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    - b. Mix lime with dry soil before mixing fertilizer.
  - 2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
    - a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
    - b. Reduce elevation of planting soil to allow for soil thickness of sod.



- H. Unchanged subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
  - 1. Remove existing grass, vegetation, and turf.
    - a. Do not mix into surface soil.
  - 2. Loosen surface soil to a depth of at least 6 inches.
    - a. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil.
    - b. Apply superphosphate fertilizer directly to surface soil before loosening.
  - 3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
  - 4. Legally dispose of waste material, including contaminated soils, grass, vegetation, and turf, off Owner's property.
- I. Finish grading:
  - 1. Grade seeding areas to a smooth, uniform surface plane with loose, uniformly fine texture.
  - 2. Grade to within plus or minus 1/2 inch of finish elevation.
  - 3. Roll and rake, remove ridges, fill depressions to meet finish grades, and ensure positive surface drainage.
  - 4. Maintain profiles and contour of subgrade.
  - 5. Limit finish grading to areas that can be planted in the immediate future.
- J. Rip topsoil that has been spread to a minimum depth of 8 inches in one direction using an agricultural ripper with tines spaced at no greater than 18 inches.
  - 1. Areas adjacent to walks, structures, curbs, etc., where the use of large mechanical equipment is difficult, shall be worked with smaller equipment or by hand.
- K. Manually spread topsoil close to plant materials and structures to prevent damage.
- L. Spread amendments, as determined by the soil test results or indicated on the Drawings, over the entire area to be seeded and incorporate into the top 6 inches of soil by disking or rototilling until a uniform mixture is obtained with no pockets of soil or amendments remaining.
- M. Restore fine grade with float drag to remove irregularities resulting from tilling operations.
  - 1. Float drag or rake in 2 directions.
  - 2. Remove any additional stones over 1 inch that have come to the surface.
  - 3. Perform drainage test by applying water with the irrigation system.
  - 4. Do not plant until the finished grade is reviewed by the Engineer.
  - 5. This review does not reduce Contractor's responsibility to provide a finished product that drains.
- N. Apply fertilizer, if necessary, after smooth raking of topsoil and prior to planting of seed.
  - 1. Apply fertilizer at a rate as determined by the soil tests or indicated on the Drawings.
  - 2. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
  - 3. Mix thoroughly into upper 6 to 8 inches of soil.



- O. Lightly water to aid the dissipation of fertilizer.
- P. Remove any additional stones over 1 inch that have come to the surface.
- Q. Moisten prepared area before planting if soil is dry.
  - 1. Water thoroughly and allow surface to dry before planting.
  - 2. Do not create muddy soil.
- R. Before planting, obtain Engineer's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- S. Tolerances: Top of topsoil plus or minus 1/2 inch.

#### **9.05 PESTICIDE APPLICATION**

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations.
  - 1. Coordinate applications with Owner's operations and others in proximity to the Work.
  - 2. Notify Owner before each application is performed.
- B. Post-emergent herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

#### **9.06 SEED**

- A. Preparation for seeding:
  - 1. Prior to seeding, if weeds exist, apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.
  - 2. Do not spray on a day when wind is detectable.
  - 3. Remove remaining vegetative matter.
  - 4. Repeat herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.
- B. Drill seeding:
  - 1. Drill seed by means of a Brillion mechanical power-drawn drill seeders, or equal, to a maximum depth of 1/4-inch followed by packer wheels or drag chains to provide smooth finish.
  - 2. Seed at the rates given below.
  - 3. Seed in 2 passes at right angles to one another.
  - 4. Sow half the seed in each pass.
  - 5. Provide markers or other means to ensure that the successive seeded strips will overlap or be separated by a space no greater than the space between the rows planted by the equipment being used.
  - 6. Do not seed during windy weather.
  - 7. Restore fine grade after seeding as requested by the Engineer.
  - 8. Remove irregularities by hand raking or rolling.
  - 9. In areas inaccessible to a drill seeder, broadcast seed by hand in 2 opposite directions.
    - a. Rake in seed after broadcasting.



- b. Do not broadcast seed during windy weather.
- 10. Seeding rates:
  - a. Seeding rates shall be as recommended by the seed supplier for drill seeded areas.
  - b. Hand and broadcast seeded areas shall receive 2 times the seeding rate indicated.
- 11. Do not seed areas in excess of that which can be mulched on same day.
- 12. Do not sow immediately following rain, when ground is too dry, frozen, or during windy periods.
- 13. Roll seeded area with roller not exceeding 100 pounds.
- 14. Immediately following seeding and compacting, apply mulch.
- 15. Sow seed with spreader or seed drill machine.
  - a. Do not broadcast or drop seed when wind velocity exceeds 5 miles per hour.
  - b. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
    - 1) Do not use wet seed or seed that is moldy or otherwise damaged.
    - 2) Do not seed against existing trees.
      - a) Limit extent of seed to outside edge of planting saucer.
- 16. Sow seed at a total rate as recommended by the seed supplier.
- 17. For any Broadcast seeded areas rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- 18. Protect seeded areas with erosion-control mats where indicated on the Drawings; install and anchor according to manufacturer's written instructions.
- 19. In final preparations for seeding, use level board not less than 8 feet in length to ensure true and accurate grades.
- 20. Finish grade lawn areas to 2 inches below elevation of adjacent paving.
- 21. Do not take heavy objects, except lawn rollers, over areas that have been prepared for seeding.
- 22. Prior to seeding, Engineer shall accept areas for grade and compaction.
- C. Seed establishment on slopes:
  - 1. Protect seeded areas with slopes and swales exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
  - 2. Roll fabric onto slopes without stretching or pulling.
  - 3. Lay fabric smoothly on surface in direction of water flow.
  - 4. Bury top end of each section in 6-inch deep excavated topsoil trench.
  - 5. Provide 6-inch overlap of adjacent rolls.
  - 6. Backfill trench and rake smooth, level with adjacent soil.
  - 7. Secure outside edges and overlaps at 24-inch intervals with stakes.
  - 8. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
  - 9. For sides of ditches, lay fabric laps in direction of water flow.
  - 10. Lap ends and edges minimum 6 inches.
- D. Satisfactory seed areas:
  - 1. Turf installations shall meet the following criteria as determined by the Engineer:
  - 2. Acceptance for soil preparation (topsoil installation) and final grading shall be given by the Engineer upon satisfactory completion of each section or area prior to seeding.





3. Final completion for seeded areas shall be given by the Engineer as soon as there is an even stand of grass with germination over 100 percent of the site.
    - a. Warranty:
      - 1) Guarantee all seeding to be alive and healthy for 2 years following date of final completion by the Engineer.
      - 2) Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
      - 3) All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
      - 4) The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
      - 5) Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
      - 6) Maximum single bare spot size of non-irrigated seed is 1 square foot.
      - 7) All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
    - b. Re-seed areas that in the opinion of the Engineer do not meet the preceding standards.
  4. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.
- E. Seeded area maintenance:
1. Maintain and establish seeded area by watering, noxious weed management, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable seeded area.
  2. Roll, regrade, and replant bare or eroded areas and mulch.
  3. Provide materials and installation the same as those used in the original installation.
    - a. Fill in as necessary soil subsidence that may occur because of settling or other processes.
      - 1) Replace materials and seeded area damaged or lost in areas of subsidence.
    - b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
    - c. Apply treatments as required to keep seeded area and soil free of pests and pathogens or disease.
      - 1) Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
  4. Watering: Install and maintain temporary piping, hoses, and seeded area watering equipment to convey water from sources and to keep meadow uniformly moist.
  5. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch.
    - a. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
  6. Water meadow with fine spray at a minimum rate of 1/2 inch per week or more for seed establishment for 6 weeks after planting or until seed establishment is determined by the Engineer (whichever is longer) unless rainfall precipitation is adequate.



## 9.07 MULCH

- A. Straw mulching:
  - 1. After seeding, apply 2 tons of small grained straw per acre.
    - a. Spread straw to give a 1/2 inch to 1 inch thick layer of mulch (3 to 5 straws thick) and crimp in 2 to 3 inches with a mechanical crimper or other approved equipment.
  - 2. Hand crimping shall be employed in areas inaccessible to crimper, or where excessive slopes would cause unsatisfactory results.
  - 3. Crimping against the contour shall not be accepted.
  - 4. Apply water and tackifier with a fine spray immediately after each area has been mulched.
    - a. Saturate to 4 inches of soil.

## 9.08 HYDRO-MULCH

- A. Hydro-mulching:
  - 1. Hydro-mulch all dormant seeded areas with a slurry mix containing additional tacifier.
  - 2. Utilize hydraulic equipment with nozzle adapted for hydraulic mulching with storage tanks having means of estimating volume used or remaining in the tank.
  - 3. Hydro-mulch shall consist of tacifier applied at a rate of 100 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
    - a. Hydro-mulch applied to dormant seeded areas shall consist of tacifier applied at a rate of 150 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
  - 4. Protect seeded areas with slopes not exceeding 1:4 by spreading straw mulch.
    - a. Spread uniformly at a minimum rate of 2 tons per acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas.
    - b. Spread by hand, blower, or other suitable equipment.
      - 1) Anchor straw mulch by crimping into soil with suitable mechanical equipment.
      - 2) Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gallons per 1,000 square feet.
        - a) Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas.
        - b) Immediately clean damaged or stained areas.
  - 5. Protect seeded areas from hot, dry weather or drying winds by applying hydro mulch and tackifier within 24 hours after completing seeding operations.
    - a. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch and roll surface smooth.

## 9.09 HYDROSEED

- A. Installation:
  - 1. Surface preparation:
    - a. Area to be hydroseeded to be weed free and have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of 2 to 4 inches.



- b. Do not use any implements that will create an excessive amount of downward movement or clods on sloping areas.
      - c. Hydroseed bed may be prepared at time of completion of earth-moving work.
    - 2. Application:
      - a. Mark test plots to calibrate equipment and rate of vehicle.
        - 1) Continue test operations until satisfied with performance of even, smooth application.
      - b. Apply seed with wood cellulose fiber at 500 pounds per acre.
        - 1) Do not allow seed to stay within slurry longer than 30 minutes.
      - c. Immediately after seeding, apply wood fiber mulch at 3,000 pounds per acre with a tackifier adhesive at 75 pounds per acre.
        - 1) Mixture to be sufficient green in color to determine coverage.
        - 2) Use nontoxic dye that is water-soluble.
      - d. Foot traffic on hydroseed is not permitted.
    - 3. Slurry preparation:
      - a. Prepare slurry at project site, using potable water.
        - 1) Plant effluent is acceptable.
      - b. Dispose of any slurry that has not been used within 2 hours at a location off-site at Contractor's expense.
- B. Hydroseed watering:
  - 1. Provide temporary watering system or apply water with a water truck acceptable to Engineer.
    - a. Plant effluent may be used for hydroseed watering.
    - b. Do not place irrigation lines on top of embankment slope.
  - 2. Germination stage:
    - a. Initiate watering sequence within 24 hours after hydro-mulching planted areas. Leave water on long enough to moisten soil thoroughly to a depth of the fiber, taking care not to supersaturate or wash fiber or soil particles off the slopes. Observe irrigation system continually while in operation.
    - b. Contractor to repair all seed washing or erosion immediately.
    - c. Irrigate fiber and seed lightly and frequently to maintain optimum moisture content for maximum germination. Determine irrigation sequence according to air temperature, prevailing wind velocity, soil texture, orientation, and other logistical problems.
    - d. Keep soil moist at all times during germination period. Continue irrigation sequence until seedlings have grown beyond the germination stage, approximately 30 to 60 days.
- C. Establishment stage:
  - 1. Reduce watering frequency while increasing duration of the water sufficiently to allow for maximum water penetration for the expanding root system. Take care not to cause erosion.
  - 2. Precise watering reduction program to be determined by Contractor.
  - 3. Hardening-off stage:
    - a. Reduce irrigation frequency while increasing the duration of each water cycle.
    - b. A specific watering program to be approved by Owner.
- D. Hydroseed fertilizer:



1. Distributed uniformly over seed bed and incorporated into the soil. Incorporation may be part of the seed bed preparation or as part of the seeding operation, unless seed is broadcast.
    - a. If fertilizing is a part of the seed bed preparation, do not fertilize more than 15 days prior to seeding.
  2. Apply fertilizer at 250 pounds per acre.
- E. Hydroseed mowing:
1. Contractor to mow seeded areas prior to spring germination.
- F. Hydroseed maintenance:
1. Maintain hydroseed areas for 1 year following final acceptance.
  2. Maintenance involves watering, mowing, and any other activities required to establish and maintain the ground cover.

#### **9.10 EROSION CONTROL BLANKETS**

- A. Preparation for erosion-control materials:
1. Install erosion-control materials in accordance with manufacturers recommendations.
  2. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions.
    - a. Fasten as recommended by material manufacturer.
  3. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
  4. Erosion control hydroseeding to be applied to all stormwater ditches, stormwater pipe inlets, stormwater pipe outlets, and as indicated on the Drawings.
    - a. Hydroseeding shall be the last activity conducted by Contractor prior to project acceptance.
  5. Moisten prepared area before planting if surface is dry.
  6. Water thoroughly and allow surface to dry before planting.
  7. Do not create muddy soil.

#### **9.11 CLEANUP AND PROTECTION**

- A. Promptly remove soil and debris created by turf work from paved areas.
1. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly seeded areas from traffic.
1. Maintain fencing and barricades throughout initial seed establishment.
- C. Remove nondegradable erosion-control measures after grass establishment period.
- D. During landscape installation:
1. All areas shall be reasonably clean at the end of each workday.
  2. Sidewalks and other paved areas shall be swept or washed down as needed.
- E. Project completion:



1. All debris, soil, and trash resulting from landscape operations shall be removed from the site.
2. All paved areas shall be washed down.

END OF SECTION



## **SECTION 02200**

### **SITE CLEARING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Clearing, grubbing, and stripping project site.

##### **1.02 REFERENCES**

##### **1.03 DEFINITIONS**

- A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.
- B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.
- C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the Engineer.

##### **1.04 QUALITY ASSURANCE**

- A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.
- B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

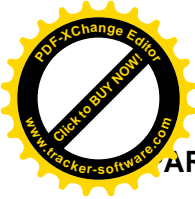
##### **1.05 PROJECT CONDITIONS**

- A. Environmental requirements:
  - 1. For suspected hazardous materials found: As specified in Section 01354 - Hazardous Material Procedures.

##### **1.06 SEQUENCING AND SCHEDULING**

- A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.





## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine site and verify existing conditions for beginning work.

### **3.02 PREPARATION**

- A. Protect existing improvements from damage by site preparation work.

### **3.03 INSTALLATION**

- A. Clearing:
  - 1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
  - 2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
  - 3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.
- B. Grubbing:
  - 1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
  - 2. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.
- C. Stripping:
  - 1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
  - 2. Replace topsoil in areas disturbed during construction.

END OF SECTION



## SECTION 02240

### DEWATERING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Installation and maintenance of dewatering systems.
  - 2. Disposal of water entering excavation or other parts of the work.

##### 1.02 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
  - 2. Dewatering design analysis. Include the following:
    - a. Evaluation of anticipated subsurface conditions.
    - b. Required well spacing.
    - c. Diameter of wells.
    - d. Depth to screen, screen height, and mesh size.
    - e. Backfill and filter pack.
    - f. Pump size.
    - g. Drawdown duration.
    - h. Drawdown and steady state flow rates.
    - i. Plans for de-silting of groundwater before discharge.
    - j. Expected settlements.
  - 3. Include water drawdown curves in dewatering calculations.
  - 4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.
  - 5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
  - 6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to finished grade.
  - 7. Provide standby power to ensure continuous dewatering in case of power failure.
- B. Dewatering shored excavations:
  - 1. Dewater from within shoring.
  - 2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
  - 3. Extend impermeable shoring below bottom of excavation sufficient amount to:
    - a. Minimize lowering of groundwater outside shoring.
    - b. Prevent unstable excavation due to piping and heave.



4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.
  5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.
- C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.
- D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.
- E. Discharge:
1. Discharge to storm drain manholes or storm drain inlets will be permitted.

### **1.03 SUBMITTALS**

- A. Dewatering plan:
1. Dewatering design analysis.
  2. Required permits.
  3. Arrangement, location, and depths of dewatering system components.
  4. Type and sizes of filters.
  5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location. For pipes discharging to manholes, provide details of pipe entry at manhole.
- B. Well construction logs. Include:
1. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
  2. Construction details.
  3. Well development procedures and results.
  4. Deviations from original design.
- C. Qualifications:
1. Dewatering contractor.
  2. Dewatering design engineer.
  3. Testing laboratory.

### **1.04 QUALITY ASSURANCE**

- A. Dewatering plan and dewatering system analysis:
1. Prepared by a qualified Civil Engineer, licensed in the state where the Project is located.
    - a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.
- B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.
- C. Testing laboratory shall meet discharge permit testing laboratory qualifications.
- D. Regulatory requirements:
1. Obtain required water discharge permits.



## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.
- B. Keep excavations reasonably free of water.
- C. Make provisions to maintain continuous dewatering:
  - 1. Provide standby power to maintain dewatering during power outages and interruptions.
  - 2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.
- D. Intercept and divert precipitation and surface water away from excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.
- E. Disposal of water:
  - 1. Dispose of water from the work in suitable manner without damage to adjacent property.
  - 2. Do not drain water into work built or under construction.
  - 3. Dispose of water in such manner that it will not be a menace to public health or safety.
- F. Wells, well points, and drain lines for dewatering:
  - 1. Provide after receiving Engineer's written acceptance.
  - 2. Fill dewatering wells, pipes, and french drains to be left in place within structure foundation limits with Class "C" concrete as specified in Section 03300 - Cast-in-Place Concrete or grout as specified in Section 03600 - Grouting.

### **3.02 CONSTRUCTION**

- A. Prior to release of groundwater to its static level: Confirm that:
  - 1. All groundwater pressure relief devices for structure are fully operational.
  - 2. Construction of structure is complete and concrete has reached its specified compressive strength.
  - 3. Backfill of structure is complete.
- B. Control release of groundwater to its static level to prevent disturbance of natural foundation soils or compacted backfills and fills and to prevent flotation or movement of structures, pipelines, or other facilities.

END OF SECTION





## SECTION 02260

### EXCAVATION SUPPORT AND PROTECTION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

##### 1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
  - 1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

##### 1.03 DEFINITIONS

- A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
- B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.
- C. Support levels: Level of tiebacks, wales, rackers, bottom of excavation, and other types of support.

##### 1.04 SYSTEM DESCRIPTION

- A. Where General Engineering Design Practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
  - 1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
  - 2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.
- B. Design requirements:
  - 1. General:
    - a. For trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in.
      - 1) Perform design pursuant to general engineering design practice.
    - b. Dewatering:
      - 1) Dewater soil inside shoring as specified in Section 02240 - Dewatering for Structures.
      - 2) Do not lower groundwater outside of shoring more than 1 foot.
      - 3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.





- c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
  - d. Minimum safety factor used for design shall not be less than 1.5.
  - e. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
  - f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
  - g. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
  - h. Generally acceptable references for design of shoring and excavations are as follows:
    - 1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
    - 2) Caltrans California Trenching and Shoring Manual.
    - 3) NAVFAC Design Manual 7.2.
    - 4) NAVFAC Design Manual 7.3.
    - 5) USS Steel Sheet Piling Design Manual.
2. Soldier piles and lagging:
- a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
  - b. Provide full face lagging all around penetrations through lagging.
  - c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 02312 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
  - d. Assumed effective width for passive soil resistance:
    - 1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
    - 2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
    - 3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
  - e. Fill voids behind lagging with gravel or other material acceptable to Engineer.
  - f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
    - 1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
    - 2) Do not eccentrically load structural section of soldier piles or wales.
  - g. Design soldier piles for downward loads including vertical loads from tieback anchors.
3. Soil anchors, rock anchors, and deadman anchors:
- a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
  - b. Proof load all production anchors to 125 percent of calculated load from shoring.
  - c. Lock off production anchors at calculated load from shoring.



- d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
    - e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
    - f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.
  - 4. Set inside face of shoring back from structure not less than greater of following:
    - a. 5 feet from face of wall.
    - b. 2 foot 6 inches from edge of foundation.
    - c. Depth of excavation below bottom of foundation.
- C. Performance requirements:
  - 1. General:
    - a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
    - b. Specified provisions:
      - 1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
      - 2) Represent minimum requirement for:
        - a) Number and types of means needed to maintain soil stability.
        - b) Strength of such required means.
        - c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
  - 2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
  - 3. Provide support for trench excavations for protection of workers from hazard of caving ground.
  - 4. Provide shoring:
    - a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
      - 1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
      - 2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
    - b. For trenches 5 feet and deeper.
    - c. For trenches less than 5 feet in depth, when there is potential for cave-in.
    - d. Where indicated on the Drawings.
  - 5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
    - a. Using stiff shoring systems.



- b. Following appropriate construction sequence.
- c. Using shoring system that is tight enough to prevent soil loss through the shoring.
- d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
- e. Design for safety factor of not less than 1.50.
- f. Providing surface runoff routing and discharge away from excavations.
- g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
- h. Where sheet piling is used, use interlocking type sheets:
  - 1) Sheet piles shall be continuous and driven in interlock.
  - 2) If bottom of the excavation is located below the water table, use "ball and socket" or "thumb and finger" type interlock.
- i. Not applying shoring loads to existing structures and other improvements.
- j. Not changing existing soil loading on existing structures and other improvements.
- k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds **1/2** inch before wales are loaded.

## 1.05 SUBMITTALS

- A. Shop drawings and calculations:
  - 1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
  - 2. Sketches showing the condition at various stages of installation and removal of shoring.
  - 3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
  - 4. When utilities penetrate shoring, show location of penetrations on elevation of all sides of shoring.
  - 5. Show details for ground support and sealing around utility penetrations.
  - 6. Indicate method used for installing driven shoring.
- B. Control points and schedule of measurements:
  - 1. Submit location and details of control points and method and schedule of measurements.
  - 2. Survey data.
- C. Detailed sequence of installation and removal of shoring:
  - 1. Consider effects of ground settlement in sequence of installation and removal of shoring.
  - 2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.
- D. Submit submittals for excavation support and protection as complete package and include all items required in this Section:
  - 1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.



- E. Submit dewatering submittals as specified in Section 02240 - Dewatering for Structures with submittals for excavation support and protection.

## **1.06 SEQUENCING**

- A. Do not begin construction of any shoring or excavation operations until:
  - 1. Submittals for shoring and dewatering have been accepted.
  - 2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
  - 3. Materials necessary for installation are on site.
- B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 CONSTRUCTION**

- A. Installation of shoring:
  - 1. Install means for providing safe and stable excavations as indicated in submittals.
- B. Removal of shoring:
  - 1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of Work.
  - 2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
  - 3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
    - a. Inject grout starting at bottom of void and progressively fill void to grade.
    - b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
  - 4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.
- C. Control points:
  - 1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
    - a. Set control points on shoring support system:
      - 1) Set points at distances not exceeding 25 feet at each support level.
  - 2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.



3. Perform horizontal and vertical survey and measurement of control points at least once every week:
    - a. Field notes shall show current measurement and change in measurement from first measurement taken.
  4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
- D. Maintenance:
1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
  2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION



## SECTION 02300

### EARTHWORK

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
  - 2. Backfilling and compacting under and around structures.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN m/m<sup>3</sup>)).
  - 3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

##### 1.03 DEFINITIONS

- A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
- B. Embankments: Dikes, levees, berms, and similar facilities.
- C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

##### 1.04 SYSTEM DESCRIPTION

- A. Performance requirements:
  - 1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
  - 2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
  - 3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.





1.05

## **SUBMITTALS**

- A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.
- B. Excavation plan.
- C. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.
- D. Test reports:
  - 1. Submit certified test reports of all tests specified to be performed by the Contractor.
  - 2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering registered in the state where the project is located.

## **1.06 QUALITY ASSURANCE**

- A. Initial compaction demonstration:
  - 1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
    - a. 50 cubic yards of backfill adjacent to structures.
    - b. 100 cubic yards of embankment work.
    - c. 100 cubic yards of fill.
    - d. 50 cubic yards of roadway base material.
    - e. 100 cubic yards of road fill.
  - 2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
  - 3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."
- B. Contractor shall perform all work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP) and as specified in Section 01355A – Stormwater Pollution Prevention Construction Activities: Best Management Practices.

## **1.07 SEQUENCING AND SCHEDULING**

- A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.
- B. If necessary, stockpile excavated material in order to use it at specified locations.
- C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.



## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Water for compacting: Use water from source acceptable to Engineer.
- B. Soil and rock materials:
  - 1. General:
    - a. Provide aggregate base course, controlled low-strength material, granular fill material native material, and sand where specified or indicated on the Drawings.
    - b. If suitable surplus materials are available, obtain native material from cut sections or excavations.
  - 2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 3. Granular fill material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 4. Native material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 5. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Materials (CLSM).
- D. Geotextile fabrics:
  - 1. Stabilization fabric: As specified in Section 02620 – Stabilization Fabric.
  - 2. Stabilization fabric shall be used under backfill at concrete structures and pavement, under aggregate base course at paved areas, and under aggregate base course at gravel surfaced areas.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions:
  - 1. Character and quantity of material:
    - a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
    - b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
    - c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
    - d. Include wasting of excess material, if required, in cost of work to be performed.

### **3.02 PREPARATION**

- A. Backfills:
  - 1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts,



- hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompect scarified areas to density specified before placing backfill material or concrete.
  - 3. Do not place backfill against walls until:
    - a. Walls have been cast full height of structure and concrete has reached the specified strength.
    - b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
  - 4. Prior to backfilling:
    - a. Remove all forms.
    - b. Clean all trash and debris from the excavation site.
  - 5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.
- B. Fills:
- 1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompect scarified areas to density specified for compacted fills before placing of fill material or concrete.
- C. Roadway fills:
- 1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompect scarified areas to density specified for roadway fills before placing of roadway fill material.

### **3.03 INSTALLATION**

- A. General:
- 1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
  - 2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
  - 3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
  - 4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.
- B. Borrow area: There is no borrow area on Project site.
- 1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.
  - 2. There will be no additional cost to the Owner for use of imported material.



C. Compaction:

1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1557, or with ASTM D6938.
4. Maximum density obtained in laboratory when tested in accordance with ASTM D1557.
5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
6. Compact to percentage of maximum density as follows:
  - a. Backfill adjacent to structures: 95 percent.
  - b. Backfilling voids: 95 percent.
  - c. Other areas: 85 percent.
  - d. Under present and future structures: 95 percent.
  - e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
  - f. Upper 6 inches of cuts: 95 percent.
  - g. Fills: 95 percent.

D. Dewatering: As specified in Section 02240 - Dewatering.

E. Excavation:

1. Blasting: Not permitted.
2. Excavations for structures:
  - a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure, including trenching for piping and all work incidental thereto.
  - b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
  - c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
  - d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
    - 1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
    - 2) Under footings: Restore to the proper elevation using one of the following:
      - a) Aggregate base course.
  - e. Excavation width:
    - 1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.



- 2) Do not undercut slopes.
- f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
3. Necessary over excavation:
  - a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
  - b. Backfill voids with material acceptable to the Engineer:
    - 1) With acceptance of the Engineer, backfill with one of the following:
      - a) Aggregate base course.
      - b) Controlled low-strength material.
- F. Materials for backfills, embankments, fills, and roadway fills:
  1. General:
    - a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
  2. Backfills:
    - a. Backfill adjacent to structures, slabs, or walls: Native material Granular fill material or imported material meeting the requirements of native material granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
    - c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  3. Fills:
    - a. Native material Granular fill material or imported material meeting the requirements of native material Granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  4. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
    - a. Aggregate base course material.
- G. Placement:
  1. General:
    - a. Lines and grades:
      - 1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
      - 2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
  2. Backfills:
    - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    - c. Defective compacted backfills: Remove and recompact.



3. Fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted fills: Remove and recompact.
4. Roadway fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted roadway fills: Remove and recompact.

### 3.04 FIELD QUALITY CONTROL

#### A. Tests:

1. Confirmation tests:
  - a. Contractor's responsibilities:
    - 1) Accomplish specified compaction for backfills, fills, and other earthwork.
    - 2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
    - 3) Cost of confirmation tests: Paid for by the Contractor.
    - 4) Qualifications of Contractor's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the Engineer.
    - 5) Copies of confirmation test reports: Submit promptly to the Engineer.
  - b. Frequency of confirmation testing:
    - 1) Perform testing not less than the following:
      - a) In-place density:
        - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
        - (2) Cuts: 20 cubic yards.
        - (3) Fills: 20 cubic yards.
        - (4) Roadway fills: 20 cubic yards.
      - b) Maximum dry density versus moisture:
        - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
        - (2) Cuts: 20 cubic yards.
        - (3) Fills: 20 cubic yards.
        - (4) Roadway fills: 20 cubic yards.
2. Compliance tests:
  - a. Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
  - b. Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
  - c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
    - 1) Remove and replace materials at proper density.
    - 2) Bring density up to specified level by other means acceptable to the Engineer.





- d. Retesting:
  - 1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
  - 2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.

B. Tolerances:

- 1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
  - a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
  - b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
- 2. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
  - a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
  - b. Intent of proceeding is to avoid sandy or gravelly areas.
- 3. Finish grading of surfaces:
  - a. Reasonably smooth, compacted, and free from irregular surface changes.
  - b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
  - c. Uniformly grade areas that are not under concrete.
  - d. Finish ditches and gutters so that they drain readily.

### **3.05 ADJUSTING**

- A. Finish grades of excavations, backfills, and fills:
  - 1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

### **3.06 PROTECTION**

- A. Finish grades of backfills, cuts, excavations, and fills:
  - 1. Protect newly graded areas from erosion and deterioration by action of the elements.
- B. Ditches and gutters:
  - 1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION



## SECTION 02312

### CONTROLLED LOW STRENGTH MATERIAL (CLSM)

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Controlled low strength material (CLSM), also known as “flowable fill.”

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
  - 1. 229R - Report on Controlled Low-Strength Materials.
  - 2. 301 - Specifications for Structural Concrete.
- B. ASTM International (ASTM):
  - 1. C94 - Standard Specification for Ready Mix Concrete.
  - 2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
  - 3. C150 - Standard Specification for Portland Cement.
  - 4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
  - 5. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
  - 6. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  - 7. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
  - 8. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
  - 9. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

##### 1.03 SYSTEM DESCRIPTION

- A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.
- B. Performance requirements:
  - 1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.
  - 2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
  - 3. Wet density: Not greater than 132 pounds per cubic foot.
  - 4. Slump, measured in accordance with ASTM C143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.



## **04 SUBMITTALS**

- A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
  - 1. Cement: Mill tests. Indicate alkali content representative of each shipment.
  - 2. Fly ash: Identify source and type of fly ash.
  - 3. Water: Identify source and quality if not from a municipal treatment source.
  - 4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.
  - 5. Aggregate:
    - a. Submit source, type, and sieve analyses.
    - b. Resubmit at any time there is a significant change in grading of materials.
- B. Mix design:
  - 1. Submit full details, including mix design calculations for mix proposed for use.
  - 2. Trial batch test data:
    - a. Submit data for each test cylinder.
    - b. Submit data that identifies mix and slump for each test cylinder.

## **1.05 DELIVERY, STORAGE AND HANDLING**

- A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.
- B. Store admixtures in accordance with the manufacturer's recommendations.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Cement:
  - 1. Portland cement in accordance with ASTM C150 Type I or Type II.
  - 2. Having total alkali content not more than 0.60 percent.
- B. Fly ash: Class C or Class F fly ash in accordance with ASTM C618.
- C. Water:
  - 1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
- D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM.
  - 1. Air entraining admixture: In accordance with ASTM C260.

### **2.02 MIXES**

- A. See System Description for performance requirements of the plastic and hardened mix.



## 2.03 SOURCE QUALITY CONTROL

- A. Trial batch:
  - 1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
  - 2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
  - 3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in the this Section.
- B. Trial batch testing:
  - 1. Determine slump in accordance with ASTM C143, with the following modifications:
    - a. Do not rod the concrete material.
    - b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
  - 2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
    - a. Provide cylindrical test specimens, each 6-inches in diameter by 12-inch high.
    - b. Provide a minimum of 8 cylinders for testing of each trial batch.
    - c. Fill the molds to overflowing and tap sides lightly to settle the mix.
    - d. Do not rod the mix for consolidation in the cylinder.
    - e. Strike off the excess material.
  - 3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
  - 4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested.
    - a. Perform the capping carefully to prevent premature fractures.
    - b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
  - 5. Provide compressive strength tests:
    - a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
    - b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
- C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced.
  - 1. All the trial batches and acceptability of materials shall be paid by the Contractor.
  - 2. After acceptance, do not change the mix design without submitting a new mix design, trial batches, and test information.



## **ART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.
- B. Remove debris foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

### **3.02 INSTALLATION**

- A. Pipes and trenches.
  - 1. Install cellular concrete as indicated on the Drawings and specified.
  - 2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
  - 3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.
  - 4. Place CLSM at specified access points in the abandoned in-place pipe.
- B. Soil preparation:
  - 1. Prior to placement of CLSM, prepare underlying soils as follows:
    - a. Scarify surface to a depth of 8 inches.
    - b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D1557.
    - c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D1557.

### **3.03 MEASURING, BATCHING, MIXING AND TRANSPORTING**

- A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.
- B. Mix until there is uniform distribution of materials.
- C. Discharge mixer completely prior to recharging.
- D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

### **3.04 PLACING**

- A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.
- B. Maintain fluid properties of the mix during placement.
  - 1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
  - 2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
  - 3. Handle and place CLSM using methods that minimize segregation of the mix.



4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.

C. Lifts:

1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.

D. Water conditions:

1. Do not place CLSM in standing or flowing water.
2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
3. Do not submerge CLSM in water within 24 hours after placement.

E. Manage CLSM bleed water.

1. Grade top surface of CLSM to drain away from the fill.
2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

### **3.05 CURING AND PROTECTION**

A. Curing:

1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.

B. Protect CLSM from:

1. Damage from the elements.
2. Damage of any nature during surrounding construction operations.
3. Freezing: Do not use salt, manure, or other chemicals to provide cold.

### **3.06 FIELD QUALITY CONTROL**

- A. Provide quality control over the Work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan and as specified in this Section.
- B. General:
1. Engineer inspection and acceptance required prior to placement.
  2. Make provisions for and furnish all material for the test specimens, and provide manual assistance in preparing said specimens.

### **3.07 FIELD QUALITY ASSURANCE**

- A. Provide quality control over the work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan.
- B. Field inspections:
1. Engineer shall provide on-site inspection for the Work of this Section.





2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
  3. Required inspections:
    - a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
  4. Record of inspections.
- C. Field sampling and testing:
1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
  2. Required tests:
    - a. Air content: Prepare sample and test in accordance with ASTM D6023
    - b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832.
      - 1) Prepare 6-inch diameter by 12-inch high specimens for testing.
        - a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
        - b) Prepare and test not less than 3 cylinders for each set.
        - c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
        - d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
      - 2) Place the cylinders in a safe location away from construction activities.
        - a) Protect cylinders from bumping and impact.
        - b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
        - c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.
      - 3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
        - a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
        - b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
      - 4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
      - 5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.
      - 6) Cap and test for compressive strength in accordance with ASTM D4832.
        - a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
        - b) Test 1 cylinder at 7 days and 2 at 28 days.
      - 7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.



### **3.08 NON-CONFORMING WORK**

- A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.
- B. Engineer may:
  - 1. Reject CLSM represented by those test specimens and require its removal and replacement.
  - 2. Require modification of the mix design to provide CLSM with the properties specified.
- C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION





## **SECTION 02318**

### **TRENCHING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Trench excavation and trench backfill.

##### **1.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>).
  - 3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

##### **1.03 SUBMITTALS**

- A. As specified in Section 01330 - Submittal Procedures.
- B. Product data on soils and aggregates.
  - 1. Material source.
  - 2. Gradation.
  - 3. Test data to demonstrate compliance with this Section.
- C. Samples:
  - 1. Provide 50-pound sample of materials when requested by the Engineer.
- D. Confirmation testing:
  - 1. Certification of Contractor's testing laboratory.
  - 2. Record copy report for tests performed by Contractor's testing laboratory.

##### **1.04 DEFINITIONS**

- A. Backfill: Material placed in trench above the pipe embedment zone.
- B. Bedding: Material placed under, around, and over pipes or ducts in trenches.
- C. Center bedding: Material placed at the bottom of the trench directly under the center of the pipe to provide a malleable resting surface.
- D. Fine grading: Material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.



- E. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
- F. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
- G. Lift: A layer of soil or aggregate material, measured before compaction.
- A. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
- B. Maximum density, field compaction: Soil density and water content when tested in accordance with ASTM D1556.
- C. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
- D. Pipe embedment zone: Includes bedding, fine grading, center bedding, and haunch zone.
- E. Pipe foundation: Material placed at the bottom of trench to provide support.
- F. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.
- G. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. As specified in Section 02050 - Soils and Aggregates for Earthwork.
- B. Class C concrete: As specified in Section 03300 - Cast-in-Place Concrete.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Material (CLSM).

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.



### 3.02 DEWATERING

- A. As specified in Section 02240 - Dewatering.

### 3.03 TRENCH EXCAVATION

- A. Excavate bottom of trench to depth indicated on the Drawings.
- B. Areas of new fill or embankment:
1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
  2. Excavate through fill for pipe trench.
- C. Trench widths as specified in the following table:

Buried Pipe Or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

- D. Potable water pipe and appurtenances:
1. Lay in trenches separate from those used for sewers.
  2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.

### 3.04 TRENCH BACKFILL - GENERAL

- A. Trench area terminology and locations as indicated on the Drawings.
- B. Place material, except CLSM and concrete, in maximum 6 inch lifts, measured before compaction.
- C. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

### 3.05 PIPE FOUNDATION

- A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.
1. Prepare pipe foundation, with any unauthorized excess excavation below elevation indicated on the Drawings, at no additional cost to Owner.
- B. If bottom of trench excavation consists of soil:
1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.





2. Materials and placement:
  - a. Recompact scarified material to 95 percent of maximum density.
- C. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
  1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
  2. Materials:
    - a. CLSM.
    - b. Class C concrete.
- D. If bottom of trench excavation consists of unacceptable material:
  1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
  2. Material and placement:
    - a. Aggregate base course material compacted to 95 percent of maximum density.
      - 1) Maximum particle size for backfill material limited as specified in the following table:

Buried Pipe	Maximum Particle Size
Nominal Pipe Diameter: 6 inch to 8 inch	3/4 inch
Nominal Pipe Diameter: 10 inch to 16 inch	1 inch
Nominal Pipe Diameter: Greater than 18 inch	1 1/2 inches

### 3.06 PIPE EMBEDMENT ZONE

- A. General:
  1. Pipe displacement:
    - a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
    - b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
  2. Depressions for joints or couplings:
    - a. Excavate holes in graded trench bottom.
    - b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
- B. Rigid pipe:
  1. Fine grading:
    - a. Compacted depth below bottom of pipe: 6 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
  2. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.



- C. Flexible pipe:
  - 1. Center bedding:
    - a. Compacted depth below bottom of pipe: 12 inch minimum.
    - b. Compacted width below bottom of pipe: 1/3 of pipe outer diameter.
    - c. Materials and placement:
      - 1) Sand bags.
      - 2) Uncompacted sand at uniform density, minimize compaction.
  - 2. Haunch zone:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.
  - 3. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.

### 3.07 BACKFILL

- A. Trenches:
  - 1. Materials and placement:
    - a. Native soil compacted to 95 percent maximum dry density.
    - b. Imported fill compacted to 95 percent maximum dry density.
    - c. Aggregate base course compacted to 95 percent maximum dry density.
    - d. CLSM.
- B. Trenches in rock:
  - 1. Backfill to top of rock.
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.
  - 2. Backfill from top of rock to grade, if applicable:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent of maximum density.
- C. Trenches below or within 10 feet of the outside perimeter of structures:
  - 1. Backfill within aggregate base course below structure.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- D. Trenches in roadways and paved areas:
  - 1. Backfill trench to underside of pavement.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- E. Trenches in areas outside the improved section of roadways or in open country:
  - 1. Backfill to finished grade.



2. Materials and placement:
  - a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.
- F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
  1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
    - a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
    - b. Materials and placement:
      - 1) CLSM, unless otherwise indicated on the Drawings.
  2. Backfill remainder of trench:
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.

### **3.08 EXCESS MATERIAL**

- A. Remove excess excavated material from the Project site as specified in Section 02300 - Earthwork.

### **3.09 FIELD QUALITY CONTROL**

- A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.
- B. Confirmation tests: As specified in Section 02300 - Earthwork.
  1. Minimum frequency of confirmation testing:
    - a. At each test location include tests for each type or class of backfill from bedding to finished grade.
    - b. For trenches: 1 location every 200 linear feet.
    - c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
    - d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
    - e. Crossing paved roads: 1 location at each crossing.
    - f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
- C. Compliance tests:
  1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
  2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
    - a. Remove and replace backfill at the proper density.
    - b. Other means acceptable to the Engineer.
  3. Retesting:
    - a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.



- b. Contractor's confirmation tests during performance of remedial work:
  - 1) Performance: Perform tests in manner acceptable to the Engineer.
  - 2) Frequency: Double amount specified for initial confirmation tests.

D. Piping system testing:

- 1. As specified in Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 02600

### CONCRETE MANHOLES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Manhole frames and covers.
  - 2. Manhole grade rings.
  - 3. Manholes cones and risers.
  - 4. Manhole bases.

##### 1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO).
  - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
  - 1. A48 - Standard Specification for Gray Iron Castings.
  - 2. C33 - Standard Specification for Concrete Aggregates.
  - 3. C150 - Standard Specification for Portland Cement.
  - 4. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
  - 5. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
  - 6. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
  - 7. C923 - Standard Guide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.
  - 8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
- C. International Organization of Standardization (ISO):
  - 1. 9001 - Quality Management Standard.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings:
  - 1. Manufacturer's catalog data and details of following items for approval:
    - a. Frame and covers.
    - b. Grade rings.
    - c. Manhole cones and risers.
    - d. Manhole bases, if precast.
  - 2. Manhole construction details, jointing methods, connection details, materials, and dimensions.
  - 3. Repair procedures and details.





- C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.
- D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.
- E. Sealed drawings and design calculations by a registered Professional Engineer licensed in the State where the project is located.
- F. Certificates
  - 1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
  - 2. Manufacturer's Certificate of Source Testing.

#### **1.04 PRODUCT REQUIREMENTS**

- A. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
  - 1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
  - 2. Dragging or dropping the manhole components shall not be allowed.
- B. Source testing.
  - 1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
    - a. In lieu of this experience, witness of tests by up to 3 full-time Owner representatives.
  - 2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
  - 3. Complete required testing in accordance with ASTM C478.
  - 4. Provide the Manufacturer's Certificate of Source Testing.

#### **1.05 DESIGN CRITERIA:**

- A. Manholes shall not include steps.
- B. Manhole lids: Locking (watertight) type.
- C. Manhole bases:
  - 1. Constructed in accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
- D. Manhole riser:
  - 1. In accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
  - 2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.
- E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.



- F. Manhole systems:
  - 1. Provided by a single manufacturer.
- G. Frames and covers:
  - 1. Provided by a single manufacturer unless approved by the Engineer.

## **1.06 WARRANTY**

- A. As specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Manhole grade rings, cones, and risers: One of the following or equal.
  - 1. Peterson Concrete.
- B. Manhole frames and covers: Manufacturers: One of the following or equal.
  - 1. East Jordan Iron Works – Model V2418.
  - 2. Neenah Foundry Company.

### **2.02 BASIS OF DESIGN**

- A. Design in accordance with local jurisdiction requirements and Little Rock Water Reclamation Authority Standard Details, including but not limited to the following:
  - 1. Manhole frames and covers.
  - 2. Manhole diameter tolerance.
  - 3. Manhole length.
  - 4. Manhole cover bolting.
  - 5. Manhole backfill.
- B. Structural design calculations:
  - 1. Load rating of manhole:
    - a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
  - 2. Resist buoyancy:
    - a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
    - b. Depths will be as indicated on the Drawings.
    - c. Refer to the geotechnical report for soil condition including fully saturated soil conditions.
- C. Manholes, grade rings, risers, and bases:
  - 1. Manhole:
    - a. Nominal sizes as indicated on the Drawings.
  - 2. Grade rings:
    - a. At least 1 but not more than 2 grade rings shall be used.
    - b. Maximum total distance from top of cone section to final grade: In accordance with Little Rock Water Reclamation Authority Standard Details.



3. Cone and riser sections:
  - a. As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
  - b. Cone sections shall be concentric.
4. Manhole bases:

As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
- D. Threaded lifting inserts:
  1. Design inserts to be fully threaded:
    - a. Do not fully penetrate through entire manhole wall.
  2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
  3. Design with minimum safety factor of 4.0.
  4. Do not use reinforcing steel bars.

## 2.03 MATERIALS

- A. Cast iron manhole frames and covers.
  1. In accordance with ASTM A48 and Little Rock Water Reclamation Authority Standard Details.
  2. Covers: Bolted (Watertight) as specified.
  3. Concrete collars: As indicated on the Drawings.
- B. Manhole bases, risers, and grade rings:
  1. Cement: Type II portland cement in accordance with ASTM C150.
  2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
  3. Sections: Steel reinforced.
  4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
  5. Top and bottom of sections: Parallel.
  6. In accordance with Little Rock Water Reclamation Authority Standard Details.
- C. Joint sealant:
  1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
  2. Manufacturers: One of the following or equal.
    - a. Tylox Superseal.
    - b. Kent Seal - Hamilton Kent Corp.
- D. Exterior joint wrap:
  1. Butyl based seal that is self-priming, self-sealing, and permanently flexible designed to create a high-performance seal in precast structures.
  2. Sealant shall provide a flexible watertight seal around perimeter of joint.
  3. Seal shall be highly resistant to temperature extremes and acid or caustic environments.
  4. Width = 6" minimum.
  5. Manufacturers: One of the following or equal.
    - a. Sealing Systems Inc. - Infi-Shield Gator Wrap.
    - b. Trelleborg – Bidco External Joint Wrap.



## **2.04 COMPONENTS**

- A. Pipe stubs:
  - 1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
  - 2. Plugging stubs:
    - a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
    - b. Unless otherwise indicated on the Drawings, comply with following:
      - 1) Stubs up to and including 21 inches: Vitrified clay stoppers.
      - 2) Stubs greater than 21 inches: Brick plugs.
- B. Resilient pipe connectors:
  - 1. Unless otherwise indicated on the Drawings or specified, provide a flexible watertight compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
  - 2. Resilient pipe connectors:
    - a. Manufacturers: The following or equal.
      - 1) A-LOK Premium.
      - 2) NPC Kor-N-Seal.
- C. Threaded lifting inserts.
- D. Drop manholes:
  - 1. Construct drop manholes at locations and in accordance with details indicated on the Drawings in accordance with Little Rock Water Reclamation Authority Standard Details.
  - 2. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
  - 3. Furnish and set fittings as indicated on the Drawings.

## **2.05 IDENTIFICATION MARKINGS**

- A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
  - 1. Date of manufacture of the item.
  - 2. Name or trademark of the manufacturer.
  - 3. Internal diameter in inches.
  - 4. Number of the manhole as indicated on the Drawings.

## **2.06 QUALITY CONTROL**

- A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.
- B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the Owner or Owner's representative.
- C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
  - 1. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.



2. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe.
  - a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
  - b. Devices are subject to inspection by Engineer.
- D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.
- E. Remove rejected manholes immediately.

## **PART 3 EXECUTION**

### **3.01 MANHOLE INSTALLATION**

- A. Excavate and backfill as specified in Section 02318 - Trenching and as indicated on the Drawings.
- B. Maintain identification markings on installed pieces throughout installation.
- C. Do not use sections with chips or cracks in the joint.
- D. Engineer may inspect manhole sections, prior to installation.
- E. Repair of manhole sections damaged during installation in accordance with manufacturer's repair procedures; with the concurrence of the Engineer.
- F. Install joint sealant material in accordance with manufacturer's instructions:
  1. Completed manhole: Rigid and watertight.
- G. Fill threaded lifting inserts with grout.
- H. Lay grade rings on joint sealant with sides plumb and tops level.
- I. Set frame and covers as specified and as indicated on the Drawings.
- J. Damproofing is not required.

### **3.02 CLEANING**

- A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.
- B. After completing each manhole, remove construction material debris from inside the manhole.

### **3.03 FUNCTIONAL TESTING**

- A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.



- B. Vacuum testing in accordance with ASTM C1244.
1. Install the vacuum test head on top of the manhole.
    - a. Install and brace sealing devices on influent and effluent pipes.
  2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
  3. Compare test results with the minimum time requirements stated in the table below.
    - a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

<b><u>Minimum Elapsed Time, Minutes: Seconds</u></b>				
<b>Manhole Depth, ft.</b>	<b>Manhole Diameter, inches</b>			
	36	48	60	72
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:46	0:57
16	0:28	0:40	0:52	1:07
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:05	1:21
22	0:38	0:55	1:12	1:29
24	0:42	0:59	1:18	1:37
26	0:46	1:04	1:25	1:45
28	0:49	1:09	1:31	1:53
30	0:53	1:14	1:38	2:01

END OF SECTION







## SECTION 02621

### STABILIZATION FABRIC

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Woven stabilization fabric used for subgrade enhancement.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
  - 2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
  - 3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
  - 4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
  - 5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
  - 6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
  - 7. D4595 - Standard Test Method for Tensile Properties of Geotextiles by the wide strip method.

##### 1.03 DEFINITIONS

- A. Stabilization fabric: Woven geotextile fabric manufactured from polypropylene yarns.

##### 1.04 SUBMITTALS

- A. Product data.
- B. Samples.
- C. Quality control submittals:
  - 1. Certificates of Compliance.
  - 2. Manufacturer's Installation Instructions.

##### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection:
  - 1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.



## 06 PROJECT CONDITIONS

- A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 2x2HF.
  2. Ten Cate Geosynthetics, Mirafi HP270.

### 2.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property <sup>(1)</sup>	Test Method	Unit	Requirements <sup>(1)</sup>
Grab Tensile Strength	ASTM D4595	lbs	2640
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	80
Apparent Opening Size (AOS)	ASTM D4751	US sieve	30
Permittivity	ASTM D4491	sec <sup>-1</sup>	0.06
Flow Rate	ASTM D4491	gpm/ft <sup>2</sup>	40
(1) Minimum average roll values.			

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

### 3.02 PREPARATION

- A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

### 3.03 INSTALLATION

- A. Follow manufacturer's installation instructions and as complimented in this Section.
- B. Place the stabilization fabric smoothly without folds or wrinkles.



- C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.
- E. Do not drag stabilization fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.
- G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

#### **3.04 FIELD QUALITY CONTROL**

- A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION





## SECTION 02772

### CONCRETE CURBS, GUTTERS, AND SIDEWALKS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

##### 1.02 SYSTEM DESCRIPTION

- A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

##### 1.03 SUBMITTALS

- A. Product data: Submit data completely describing products.
- B. Samples: Submit samples when requested.

#### PART 2 PRODUCTS

##### 2.01 MATERIALS

- A. Concrete: Class A, as specified in Section 03300 - Cast-In-Place Concrete.
- B. Curb finishing mortar: 1 part portland cement to 2 parts sand.
- C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.
- D. Joint materials:
  - 1. Expansion: As specified in Section 03150 - Concrete Accessories.

#### PART 3 EXECUTION

##### 3.01 EXAMINATION

- A. Verification of Conditions:
  - 1. Verify field conditions, including subgrade condition and interferences, before beginning construction.





## 3.02 PREPARATION

- A. Surface preparation:
  - 1. Subgrade:
    - a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 02050 - Soils and Aggregates for Earthwork.
    - b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
  - 2. Forms and subgrade: Water immediately in advance of placing concrete.

## 3.03 INSTALLATION

- A. Special techniques:
  - 1. Contractor's option:
    - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
    - b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
    - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
    - d. Discontinue use of machines when results are not satisfactory to the Engineer.
- B. Forms:
  - 1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
  - 2. Thoroughly clean prior to each use and coat with form releasing material.
- C. Expansion and weakened-plane joints:
  - 1. Expansion joints:
    - a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
    - b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
    - c. Fill joints with expansion joint filler material.
  - 2. Weakened-plane joints:
    - a. Construct as indicated on the Drawings.
    - b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.
- D. Concrete:
  - 1. Placing:
    - a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
  - 2. Compacting:
    - a. Compact by mechanical vibrators accepted by the Engineer.
    - b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.



3. Form removal:
  - a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
  - b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
4. Finishing and curing: Comply with requirements as specified in Section 03366 - Tooled Concrete Finishing except as modified here:
  - a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
  - b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
  - c. Edge concrete at expansion joints to 1/4 inch radius.
  - d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
  - e. Sidewalks and ramps: Broom finish

E. Backfilling:

1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

### 3.04 FIELD QUALITY CONTROL

A. Tests:

1. Curbs and gutters:
  - a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
  - b. Correct deviations in excess of 1/4 inch.
2. Gutters:
  - a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
  - b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
  - c. Required results:
    - 1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
    - 2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

### 3.05 ADJUSTING

- A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.



- B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

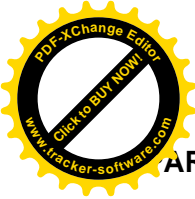
END OF SECTION



## SECTION 02939

### SEEDING

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## **ART 1    GENERAL**

### **1.01    SUMMARY**

- A.    Section includes seeding.

### **1.02    REFERENCES**

- A.    Association of Official Seed Analysts (AOSA).
- B.    United States Department of Agriculture (USDA).
- C.    United States Environment Protection Agency (EPA).

### **1.03    DEFINITIONS**

- A.    Duff layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B.    Finish grade: Elevation of finished surface of planting soil.
- C.    Manufactured topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D.    Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- E.    Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F.    Planting soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- G.    Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- H.    Surface soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.
- I.    Weeds:
  - 1.    Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Russian Thistle, Leafy Spurge, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Weed, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.



## 1.04 SUBMITTALS

- A. Product data: For each type of product indicated:
  - 1. Pesticides and herbicides: Include product label and manufacturer's application instructions specific to this Project.
  - 2. Fertilizer and organic matter: Include product label and manufacturer's application instructions specific to this Project.
  - 3. Soil amendment: Analysis.
- B. Certification of grass seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
  - 1. Certification and inspection as required by governmental authorities of each seed mixture. Include identification of source and name and telephone number of supplier.
- C. Qualification data: For qualified landscape Installer.
- D. Samples: Imported topsoil, organic matter, erosion control blanket and mulch.
- E. Product certificates: For soil amendments and fertilizers, from manufacturer.
- F. Maintenance instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

## 1.05 QUALITY ASSURANCE

- A. Installer qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
  - 1. Professional membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
  - 2. Experience: 5 years' successful experience in the installation of seeded areas similar in size to this project.
  - 3. Installer's field supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  - 4. Personnel certifications: Installer's field supervisor shall have certification in all of the following categories from the Professional Landcare Network:
    - a. Certified Landscape Technician - Exterior, with installation and irrigation specialty area(s).
  - 5. Maintenance proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
  - 6. Pesticide applicator: State licensed, commercial.
- B. Soil-testing laboratory qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter;





gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil. Refer to plan notes for number and location of soil analysis tests.

1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Engineer.
  - a. A minimum of 3 representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.
  - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated.
    - 1) State recommendations in weight per 1,000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
  - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Pre-installation conference: Conduct conference at project site.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Seed and other packaged materials:
  1. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
  2. Protect seed during delivery and storage.
  3. Seed that has become wet or otherwise damaged will not be acceptable.
- B. Deliver packaged materials in waterproof bags showing weight, chemical analysis and name or trademark of manufacturer.
  1. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, percentage of purity (PLS), percentage of germination and location of packaging.
- C. Local sourcing of seed not in sealed containers is permitted for smaller projects.
- D. Label seed bags per variety.
- E. Store materials in protected and covered storage until application or use.
- F. Bulk materials:
  1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.



- G. Truck receipts: For verification of all soil amendments and imported topsoil.
- H. Hydroseeding:
  - 1. Ensure that seed packages are packed to provide adequate protection against injury during transit.
  - 2. Deliver undamaged sealed seed bags with legible labels showing weight, analysis, vendor's name and address, and point of origin.
    - a. Label seed bags per variety.
  - 3. Deliver dry commercial process or packaging, such as fertilizer, in undisturbed original unopened containers with legible labels showing the manufacturer's guaranteed analysis or description.
  - 4. Inspect materials and packages upon delivery.
    - a. Discard damaged packages or containers immediately.
  - 5. Store materials in protected and covered storage until application or use.

## **1.07 WARRANTY**

- A. Warranty:
  - 1. Guarantee all seeding to be alive and healthy for 1 years following date of final completion by the Engineer.
  - 2. Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
  - 3. All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
  - 4. The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
  - 5. Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
  - 6. Maximum single bare spot size of non-irrigated seed is 1 square foot.
  - 7. All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
- B. Replace seeding when it is no longer in a satisfactory condition or do not meet the preceding standard as determined by the Engineer or the duration of the Guarantee/Warranty Period.
  - 1. Make replacements as soon as possible within the recommended seeding schedule.
- C. Replacements:
  - 1. Seed of same mix, quality and species as originally specified, as soon as possible within the recommended seeding schedule, with a new 1-year warranty commencing on date of replacement.
  - 2. Repairs and replacements shall be made at no expense to the Owner.

## **PART 2 PRODUCTS**

### **2.01 STAKES**

- A. Softwood lumber, chisel pointed.

### **2.02 SOIL AMENDMENTS AND FERTILIZERS**

- A. Apply soil amendments and fertilizer as indicated on the Drawings.



- B. Submit soil amendment and fertilizer recommendations, along with supporting soil test analysis, for Engineer approval prior to application on the site.
- C. Fertilizer:
  - 1. Uniform in composition, free flowing and suitable for application with approved equipment, of the proportions necessary to eliminate any deficiencies of topsoil, as indicated in analysis.
  - 2. Delivered to the site fully labeled according to applicable laws.
  - 3. Packaging: Display the name, tradename, trademark and warranty of the provider.
- D. Fertilizer grade description format:
  - 1. Three sets of 2-digit numbers.
  - 2. Numbers represent the percent by weight of nutrients.
  - 3. First number is the amount of nitrogen (N).
  - 4. Second number is the amount of phosphate (P<sub>2</sub>O<sub>5</sub>).
  - 5. Third number is the amount of potash (K<sub>2</sub>O).
  - 6. Example: 10 10 10.

### **2.03 HERBICIDE AND PESTICIDE**

- A. Submit labels for Engineer approval.
- B. Pesticides:
  - 1. Registered and approved by EPA.
  - 2. Acceptable to authorities having jurisdiction.
  - 3. Type recommended by manufacturer for each specific problem.
  - 4. As required for Project conditions and application.
  - 5. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- C. Pre-emergent herbicide (Selective and Non-Selective):
  - 1. Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- D. Post-emergent herbicide (Selective and Non-Selective):
  - 1. Effective for controlling weed growth that has already germinated.

### **2.04 WATER**

- A. Use potable water for making up seed mixture.
- B. Plant effluent may be used for hydroseeding watering and maintenance with Owner approval, as specified in this Section.

### **2.05 SOILS**

- A. Topsoil:
  - 1. Fertile soil, typical for locality, capable of sustaining vigorous plant growth.
  - 2. Taken from drained site.
  - 3. Free of subsoil, stones more than 1 inch in diameter, clay clumps, or impurities, plants weeds and roots.
  - 4. Organic content:



- a. Minimum 2 percent by mass.
5. pH value:
  - a. Minimum: 5.5.
  - b. Maximum: 7.5.

## 2.06 SEED

- A. Provide seed as indicated on the Drawings.
- B. Packaging: Provide separate bags or containers for each variety of seed.
- C. Plant seed that is appropriate for planting season.
- D. Provide seed from tested lots and delivered to project site in standard containers labeled as required by U.S. Department of Agriculture regulations and applicable state regulations.
- E. Use labels that show variety of strain of seed, degree of purity (percent), rate of germination (percent), weed content (percent), and date of test.
- F. Lawn seed:
  1. Common name: Bermuda grass (*Cynodon Dactylon*).
  2. Planted from April 15 to July 15.
  3. Fancy hulled seed.
  4. Seed mixture:
    - a. Germination minimum: 88 percent.
    - b. Pure seed minimum: 94 percent.
    - c. Weed seed maximum: 0.35 percent.
- G. Grass seed:
  1. Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
  2. Species: Match existing grass type.
  3. Seed mixture:
    - a. Germination minimum: 95 percent.
    - b. Pure seed minimum: 85 percent.
    - c. Weed seed maximum: 0.5 percent.
    - d. Other than grass seed, non-viable seed, chaff, hulls, live seed of crop plants (other than those specified), harmless inert matter, and maximum: 18 percent.
  4. Proprietary seed mix: Western Native Seed near Salida, CO.
- H. Buffalo grass mix:
  - a. Common name: "Topgun" or "Texoka" seed.
  - b. Drill rate: 90 pounds of seed per acre (2 pounds 100 feet square).
  - c. Timing: April 1 - September 1.
  - d. Cannot be hydro-mulched.
    - 1) Areas susceptible to erosion: Cover drilled seeded area with hydro-mulched fiber.
- I. Wildflower seed:
  1. Wildflower seed mix from latest crop.
  2. Seed mixture:



- a. Pure live seed content minimum: 80 percent.
3. Seed testing maximum: 6 months from planting date.
  - a. Do not use seed mix after expiration date.
4. Seeding rate:
  - a. *Lupinus luteus*: 8 pounds per acre.
  - b. *Eschscholtzia Californica*: 1.9 pounds per acre.
  - c. *Gazania Splendeus*: 12 pounds per acre.
  - d. *Clarkia Amoena*: 4.5 pounds per acre.
  - e. *Lasthenia Glabrata*: 4 pounds per acre.
  - f. *Achillea Borealis*: 3 pounds per acre.
  - g. *Stipa Pulchrum*: 3 pounds per acre.
  - h. *Gilia Capitata*: 6 pounds per acre.
  - i. *Festuca Idahoeasis*: 4 pounds per acre.
- J. Erosion control seed:
  1. Erosion control seed mix from latest crop.
  2. Seed mixture:
  3. Pure live seed content minimum: 80 percent.
  4. Seed testing maximum: 6 months from planting date.
    - a. Do not use seed mix after expiration date.
  5. Seeding rate:
    - a. Blando Brome: 20 pounds per acre.
    - b. Annual Rye: 25 pounds per acre.
    - c. Rose Clover: 20 pounds per acre.
    - d. Zorro Annual Fescue: 10 pounds per acre.

## 2.07 MULCHES

- A. As indicated on the Drawings.
- B. Straw mulch:
  1. Oats, barley, wheat or rye only.
  2. Free from weeds, foreign matter detrimental to plant life, and dry.
  3. Minimum length 10 inches long: 50 percent of straw.
  4. Not acceptable:
    - a. Hay or chopped cornstalks.
    - b. Old straw mulch which breaks during crimping.
    - c. Straw in such an advanced stage of decomposition as to smother or retard the normal growth of grass.
- C. Wood cellulose fiber mulch:
  1. Wood fibers must be capable of being evenly dispersed and suspended when agitated in water.
  2. Furnish with a biodegradable green dye to allow visual metering of its application.
  3. Not acceptable:
    - a. Substance or factor which might inhibit germination or growth of grass seed, with organic tacifier.

## 2.08 HYDRO-MULCH

- A. Hydro-mulch seed:
  1. Seeding:



- a. Mixture:
  - 1) Ratio of wood cellulose fiber, seeds and fertilizer: 4:1:6 mixture.
    - a) Fiber: 20 pounds.
    - b) Seeds: 5 pounds.
      - (1) Modify mixture according to the planting season as follows:
        - (a) February through August: 20 pounds of hulled common Bermuda grass per acre.
        - (b) August through February: combination of 15 pounds of unhulled common Bermuda and 15 pounds of unhulled Gulf Coast Annual Rye seed per acre.
    - c) Fertilizer: 30 pounds.
  - 2) Coverage: 1,000 square feet.
- b. Provide a recommendation for proposed mixture based on time of year hydro-mulch is actually performed.

B. Hydro-mulching equipment:

- 1. Manufacturers: One of the following or equal:
  - a. Bowie Industries, Inc.
  - b. Reinco.
  - c. Finn Equipment Co.
- 2. Equipment requirements:
  - a. Built-in agitation system sufficient to agitate, suspend, and homogeneously mix slurry containing fiber, fertilizers, chemicals, and seed mix.
  - b. Capable of slurry distribution line large enough to prevent stoppage.
  - c. Equipped with set of hydraulic spray nozzles which provide continuous non-fluctuating discharge of minimum 225 pounds per square inch at end of spray nozzle.

## 2.09 HYDROSEEDING MATERIALS

A. Seed mix:

- 1. Manufacturers: One of the following or equal:
  - a. Grass Growers.
  - b. Conwed Corp.
  - c. Eva Cell Co.
- 2. Seed mix from the latest crop.
- 3. Minimum pure live seed content to be 80 percent, and tested within the preceding 6 months.
- 4. Do not use seed mix after expiration date:
  - a. Blando Brome: 20 pounds per acre.
  - b. Annual Rye: 25 pounds per acre.
  - c. Rose Clover: 20 pounds per acre.
  - d. Zorro Annual Fescue: 10 pounds per acre.

B. Mulch:

- 1. Wood fiber manufactured for hydroseeding: Fiber mulch:
- 2. Manufacturers: One of the following or equal:
  - a. Grass Growers.
  - b. Conwed Corp., Fibers Div.
  - c. Eva Cell Co.





- C. Water:
  - 1. Use potable water for making up seed mixture.
  - 2. Plant effluent may be used for hydroseed watering with Owner approval as specified in this Section.
- D. Granular fertilizers:
  - 1. Manufacturers: One of the following or equal:
    - a. Sierra Chemical Co.
    - b. Green Light Co., Wonder Grow Chemicals.
    - c. Kay-Fries Chemicals.
  - 2. Fertilizer grade: 16-20-0.

## **2.10 EROSION CONTROL BLANKETS**

- A. As indicated on the Drawings.
- B. Erosion control blanket:
  - 1. Manufacturer: The following or equal:
    - a. American Excelsior Company, Curlex®.
  - 2. Jute matting, open weave.
  - 3. Regular blanket, machine produced mat of curled wood excelsior of 80 percent 6 inch or longer fiber length with a consistent width of fibers evenly distributed throughout mat.
  - 4. Photo-biodegradable extruded plastic netting cover the top side of blanket.
  - 5. Secure netting to wood excelsior by extra heavy lines of plastic woven into the width of each blanket.
  - 6. Smolder resistant with no chemical additives.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
  - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
  - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 4. Uniformly moisten excessively dry soil that is not workable, and which is too dusty.
- B. Start of work covered in this Section constitutes Contractor's approval of all existing site conditions.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.



- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by the Engineer and replace with new planting soil.

### **3.02 SITE CONDITIONS**

- A. Planting restrictions: Plant during 1 of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date.
  - 1. Irrigated seed areas: Seed from ground thaw to July 31 and September 1 to October 15.
  - 2. Non-irrigated seed areas: Seed from March 15 to July 4 and September 1 to October 15.
  - 3. Pure Warm Season Grass Seed Areas: Seed from June 1 to August 15.
  - 4. Dormant Seeding Areas: Seed from October 15 to ground freeze.
  - 5. Per seed detail.
- B. Coordinate with Contractor's work requiring access to site over existing vegetation areas.
  - 1. No trucking or moving of equipment or materials shall be permitted over completed seed areas.
- C. Coordinate with installation of all underground system piping and outlets.
- D. Weather limitations:
  - 1. Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained.
  - 2. Apply products during favorable weather conditions according to manufacturer's written instructions.

### **3.03 EXISTING VEGETATION RENOVATION**

- A. Renovate existing vegetation.
- B. Renovate existing vegetation damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  - 1. Reestablish vegetation where settlement or washouts occur or where minor regrading is required.
  - 2. Install topsoil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory vegetation areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing vegetation.
- F. Prior to seeding, irrigate for a minimum of 2 weeks to allow germination of weed seeds.
  - 1. Apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.



2. Do not spray on a day when wind is detectable.
  3. Remove remaining vegetative matter.
  4. Repeat irrigation and herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.
- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil.
1. Install new planting soil to fill low spots and meet finish grades.
- J. Apply seed and protect with hydro mulch as required for new vegetation.
- K. Water newly planted areas and keep moist until new turf is established.

### **3.04 PREPARATION**

- A. Protect existing and new structures, fences, utilities, sidewalks, paving, curbs, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
1. Protect adjacent and adjoining areas from hydromulching overspray.
  2. Protect grade stakes set by others until directed to remove them.
  3. Protect landscaping and other features remaining as final work.
- B. Limit turf subgrade preparation to areas to be planted.
- C. Newly graded subgrades:
1. Loosen/scarify subgrade to a minimum depth of 6 inches.
  2. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
  3. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted the subgrade.
  4. Tolerances: Top of subgrade plus or minus 1 inch.
- D. Prepare subgrade and eliminate uneven areas and low spots.
1. Maintain lines, levels, profiles and contours.
  2. Make changes in grade gradual. Blend slopes into level areas.
- E. Do not prepare subgrade in areas of on-site plant preservation.
- F. Do not bury foreign material beneath areas to be seeded.
- G. Remove any contaminated subgrade.
1. Apply superphosphate fertilizer directly to subgrade before loosening.
    - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    - b. Mix lime with dry soil before mixing fertilizer.
  2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.



- a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
  - b. Reduce elevation of planting soil to allow for soil thickness of sod.
- H. Unchanged subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
  1. Remove existing grass, vegetation, and turf.
    - a. Do not mix into surface soil.
  2. Loosen surface soil to a depth of at least 6 inches.
    - a. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil.
    - b. Apply superphosphate fertilizer directly to surface soil before loosening.
  3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
  4. Legally dispose of waste material, including contaminated soils, grass, vegetation, and turf, off Owner's property.
- I. Finish grading:
  1. Grade seeding areas to a smooth, uniform surface plane with loose, uniformly fine texture.
  2. Grade to within plus or minus 1/2 inch of finish elevation.
  3. Roll and rake, remove ridges, fill depressions to meet finish grades, and ensure positive surface drainage.
  4. Maintain profiles and contour of subgrade.
  5. Limit finish grading to areas that can be planted in the immediate future.
- J. Rip topsoil that has been spread to a minimum depth of 8 inches in one direction using an agricultural ripper with tines spaced at no greater than 18 inches.
  1. Areas adjacent to walks, structures, curbs, etc., where the use of large mechanical equipment is difficult, shall be worked with smaller equipment or by hand.
- K. Manually spread topsoil close to plant materials and structures to prevent damage.
- L. Spread amendments, as determined by the soil test results or indicated on the Drawings, over the entire area to be seeded and incorporate into the top 6 inches of soil by disking or rototilling until a uniform mixture is obtained with no pockets of soil or amendments remaining.
- M. Restore fine grade with float drag to remove irregularities resulting from tilling operations.
  1. Float drag or rake in 2 directions.
  2. Remove any additional stones over 1 inch that have come to the surface.
  3. Perform drainage test by applying water with the irrigation system.
  4. Do not plant until the finished grade is reviewed by the Engineer.
  5. This review does not reduce Contractor's responsibility to provide a finished product that drains.
- N. Apply fertilizer, if necessary, after smooth raking of topsoil and prior to planting of seed.



1. Apply fertilizer at a rate as determined by the soil tests or indicated on the Drawings.
  2. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
  3. Mix thoroughly into upper 6 to 8 inches of soil.
- O. Lightly water to aid the dissipation of fertilizer.
- P. Remove any additional stones over 1 inch that have come to the surface.
- Q. Moisten prepared area before planting if soil is dry.
1. Water thoroughly and allow surface to dry before planting.
  2. Do not create muddy soil.
- R. Before planting, obtain Engineer's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- S. Tolerances: Top of topsoil plus or minus 1/2 inch.

### **3.05 PESTICIDE APPLICATION**

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations.
1. Coordinate applications with Owner's operations and others in proximity to the Work.
  2. Notify Owner before each application is performed.
- B. Post-emergent herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

### **3.06 SEED**

- A. Preparation for seeding:
1. Prior to seeding, if weeds exist, apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.
  2. Do not spray on a day when wind is detectable.
  3. Remove remaining vegetative matter.
  4. Repeat herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.
- B. Drill seeding:
1. Drill seed by means of a Brillion mechanical power-drawn drill seeders, or equal, to a maximum depth of 1/4-inch followed by packer wheels or drag chains to provide smooth finish.
  2. Seed at the rates given below.
  3. Seed in 2 passes at right angles to one another.
  4. Sow half the seed in each pass.
  5. Provide markers or other means to ensure that the successive seeded strips will overlap or be separated by a space no greater than the space between the rows planted by the equipment being used.



6. Do not seed during windy weather.
7. Restore fine grade after seeding as requested by the Engineer.
8. Remove irregularities by hand raking or rolling.
9. In areas inaccessible to a drill seeder, broadcast seed by hand in 2 opposite directions.
  - a. Rake in seed after broadcasting.
  - b. Do not broadcast seed during windy weather.
10. Seeding rates:
  - a. Seeding rates shall be as recommended by the seed supplier for drill seeded areas.
  - b. Hand and broadcast seeded areas shall receive 2 times the seeding rate indicated.
11. Do not seed areas in excess of that which can be mulched on same day.
12. Do not sow immediately following rain, when ground is too dry, frozen, or during windy periods.
13. Roll seeded area with roller not exceeding 100 pounds.
14. Immediately following seeding and compacting, apply mulch.
15. Sow seed with spreader or seed drill machine.
  - a. Do not broadcast or drop seed when wind velocity exceeds 5 miles per hour.
  - b. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
    - 1) Do not use wet seed or seed that is moldy or otherwise damaged.
    - 2) Do not seed against existing trees.
      - a) Limit extent of seed to outside edge of planting saucer.
16. Sow seed at a total rate as recommended by the seed supplier.
17. For any Broadcast seeded areas rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
18. Protect seeded areas with erosion-control mats where indicated on the Drawings; install and anchor according to manufacturer's written instructions.
19. In final preparations for seeding, use level board not less than 8 feet in length to ensure true and accurate grades.
20. Finish grade lawn areas to 2 inches below elevation of adjacent paving.
21. Do not take heavy objects, except lawn rollers, over areas that have been prepared for seeding.
22. Prior to seeding, Engineer shall accept areas for grade and compaction.

C. Seed establishment on slopes:

1. Protect seeded areas with slopes and swales exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
2. Roll fabric onto slopes without stretching or pulling.
3. Lay fabric smoothly on surface in direction of water flow.
4. Bury top end of each section in 6-inch deep excavated topsoil trench.
5. Provide 6-inch overlap of adjacent rolls.
6. Backfill trench and rake smooth, level with adjacent soil.
7. Secure outside edges and overlaps at 24-inch intervals with stakes.
8. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
9. For sides of ditches, lay fabric laps in direction of water flow.
10. Lap ends and edges minimum 6 inches.





D. Satisfactory seed areas:

1. Turf installations shall meet the following criteria as determined by the Engineer:
2. Acceptance for soil preparation (topsoil installation) and final grading shall be given by the Engineer upon satisfactory completion of each section or area prior to seeding.
3. Final completion for seeded areas shall be given by the Engineer as soon as there is an even stand of grass with germination over 100 percent of the site.
  - a. Warranty:
    - 1) Guarantee all seeding to be alive and healthy for 2 years following date of final completion by the Engineer.
    - 2) Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
    - 3) All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
    - 4) The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
    - 5) Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
    - 6) Maximum single bare spot size of non-irrigated seed is 1 square foot.
    - 7) All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
  - b. Re-seed areas that in the opinion of the Engineer do not meet the preceding standards.
4. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

E. Seeded area maintenance:

1. Maintain and establish seeded area by watering, noxious weed management, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable seeded area.
2. Roll, regrade, and replant bare or eroded areas and remulch.
3. Provide materials and installation the same as those used in the original installation.
  - a. Fill in as necessary soil subsidence that may occur because of settling or other processes.
    - 1) Replace materials and seeded area damaged or lost in areas of subsidence.
  - b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
  - c. Apply treatments as required to keep seeded area and soil free of pests and pathogens or disease.
    - 1) Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
4. Watering: Install and maintain temporary piping, hoses, and seeded area watering equipment to convey water from sources and to keep meadow uniformly moist.
5. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch.
  - a. Lay out temporary watering system to avoid walking over muddy or newly planted areas.



6. Water meadow with fine spray at a minimum rate of 1/2 inch per week or more for seed establishment for 6 weeks after planting or until seed establishment is determined by the Engineer (whichever is longer) unless rainfall precipitation is adequate.

### **3.07 MULCH**

- A. Straw mulching:
  1. After seeding, apply 2 tons of small grained straw per acre.
    - a. Spread straw to give a 1/2 inch to 1 inch thick layer of mulch (3 to 5 straws thick) and crimp in 2 to 3 inches with a mechanical crimper or other approved equipment.
  2. Hand crimping shall be employed in areas inaccessible to crimper, or where excessive slopes would cause unsatisfactory results.
  3. Crimping against the contour shall not be accepted.
  4. Apply water and tackifier with a fine spray immediately after each area has been mulched.
    - a. Saturate to 4 inches of soil.

### **3.08 HYDRO-MULCH**

- A. Hydro-mulching:
  1. Hydro-mulch all dormant seeded areas with a slurry mix containing additional tacifier.
  2. Utilize hydraulic equipment with nozzle adapted for hydraulic mulching with storage tanks having means of estimating volume used or remaining in the tank.
  3. Hydro-mulch shall consist of tacifier applied at a rate of 100 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
    - a. Hydro-mulch applied to dormant seeded areas shall consist of tacifier applied at a rate of 150 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
  4. Protect seeded areas with slopes not exceeding 1:4 by spreading straw mulch.
    - a. Spread uniformly at a minimum rate of 2 tons per acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas.
    - b. Spread by hand, blower, or other suitable equipment.
      - 1) Anchor straw mulch by crimping into soil with suitable mechanical equipment.
      - 2) Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gallons per 1,000 square feet.
        - a) Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas.
        - b) Immediately clean damaged or stained areas.
  5. Protect seeded areas from hot, dry weather or drying winds by applying hydro mulch and tackifier within 24 hours after completing seeding operations.
    - a. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch and roll surface smooth.



09

## HYDROSEED

### A. Installation:

1. Surface preparation:
  - a. Area to be hydroseeded to be weed free and have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of 2 to 4 inches.
  - b. Do not use any implements that will create an excessive amount of downward movement or clods on sloping areas.
  - c. Hydroseed bed may be prepared at time of completion of earth-moving work.
2. Application:
  - a. Mark test plots to calibrate equipment and rate of vehicle.
    - 1) Continue test operations until satisfied with performance of even, smooth application.
  - b. Apply seed with wood cellulose fiber at 500 pounds per acre.
    - 1) Do not allow seed to stay within slurry longer than 30 minutes.
  - c. Immediately after seeding, apply wood fiber mulch at 3,000 pounds per acre with a tackifier adhesive at 75 pounds per acre.
    - 1) Mixture to be sufficient green in color to determine coverage.
    - 2) Use nontoxic dye that is water-soluble.
  - d. Foot traffic on hydroseed is not permitted.
3. Slurry preparation:
  - a. Prepare slurry at project site, using potable water.
    - 1) Plant effluent is acceptable.
  - b. Dispose of any slurry that has not been used within 2 hours at a location off-site at Contractor's expense.

### B. Hydroseed watering:

1. Provide temporary watering system or apply water with a water truck acceptable to Engineer.
  - a. Plant effluent may be used for hydroseed watering.
  - b. Do not place irrigation lines on top of embankment slope.
2. Germination stage:
  - a. Initiate watering sequence within 24 hours after hydro-mulching planted areas. Leave water on long enough to moisten soil thoroughly to a depth of the fiber, taking care not to supersaturate or wash fiber or soil particles off the slopes. Observe irrigation system continually while in operation.
  - b. Contractor to repair all seed washing or erosion immediately.
  - c. Irrigate fiber and seed lightly and frequently to maintain optimum moisture content for maximum germination. Determine irrigation sequence according to air temperature, prevailing wind velocity, soil texture, orientation, and other logistical problems.
  - d. Keep soil moist at all times during germination period. Continue irrigation sequence until seedlings have grown beyond the germination stage, approximately 30 to 60 days.

### C. Establishment stage:

1. Reduce watering frequency while increasing duration of the water sufficiently to allow for maximum water penetration for the expanding root system. Take care not to cause erosion.
2. Precise watering reduction program to be determined by Contractor.



3. Hardening-off stage:
  - a. Reduce irrigation frequency while increasing the duration of each water cycle.
  - b. A specific watering program to be approved by Owner.
- D. Hydroseed fertilizer:
  1. Distributed uniformly over seed bed and incorporated into the soil. Incorporation may be part of the seed bed preparation or as part of the seeding operation, unless seed is broadcast.
    - a. If fertilizing is a part of the seed bed preparation, do not fertilize more than 15 days prior to seeding.
  2. Apply fertilizer at 250 pounds per acre.
- E. Hydroseed mowing:
  1. Contractor to mow seeded areas prior to spring germination.
- F. Hydroseed maintenance:
  1. Maintain hydroseed areas for 1 year following final acceptance.
  2. Maintenance involves watering, mowing, and any other activities required to establish and maintain the ground cover.

### **3.10 EROSION CONTROL BLANKETS**

- A. Preparation for erosion-control materials:
  1. Install erosion-control materials in accordance with manufacturers recommendations.
  2. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions.
    - a. Fasten as recommended by material manufacturer.
  3. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
  4. Erosion control hydroseeding to be applied to all stormwater ditches, stormwater pipe inlets, stormwater pipe outlets, and as indicated on the Drawings.
    - a. Hydroseeding shall be the last activity conducted by Contractor prior to project acceptance.
  5. Moisten prepared area before planting if surface is dry.
  6. Water thoroughly and allow surface to dry before planting.
  7. Do not create muddy soil.

### **3.11 CLEANUP AND PROTECTION**

- A. Promptly remove soil and debris created by turf work from paved areas.
  1. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly seeded areas from traffic.
  1. Maintain fencing and barricades throughout initial seed establishment.
- C. Remove nondegradable erosion-control measures after grass establishment period.



- D. During landscape installation:
  - 1. All areas shall be reasonably clean at the end of each workday.
  - 2. Sidewalks and other paved areas shall be swept or washed down as needed.
- E. Project completion:
  - 1. All debris, soil, and trash resulting from landscape operations shall be removed from the site.
  - 2. All paved areas shall be washed down.

END OF SECTION



## SECTION 03200

### CONCRETE REINFORCING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Reinforcing bars.
    - a. Carbon steel.
  - 2. Thread bars.
  - 3. Bar supports.
  - 4. Tie wires.
  - 5. Welded wire fabric.
  - 6. Mechanical reinforcing bar couplers.

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
  - 1. 318 - Building Code Requirements for Structural Concrete and Commentary.
  - 2. SP-66 - ACI Detailing Manual.
- B. American Iron and Steel Institute (AISI).
- C. American Welding Society (AWS):
  - 1. D1.4 - Structural Welding Code - Reinforcing Steel.
- D. ASTM International (ASTM):
  - 1. A123 - Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 3. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
  - 4. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
  - 5. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
  - 6. A1064 - Standard Specification of Carbon-Steel wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
- E. Concrete Reinforcing Steel Institute (CRSI):
  - 1. Manual of Standard Practice.
- F. ICC Evaluation Service (ICC-ES):
  - 1. AC133 - Acceptance Criteria for Mechanical Connector Systems for Steel Reinforcing Bars.
  - 2. AC347 - Acceptance Criteria for Headed Deformed Bars.





03

## DEFINITIONS

- A. Architectural concrete: Concrete surfaces that will be exposed to view in the finished work.
  - 1. Additionally, for purposes of this Section, includes:
    - a. Concrete surfaces that are designated to receive paints or coatings.
    - b. Exposed concrete in open basins, channels, and similar liquid containing structures: Surfaces shall be considered exposed to view if located above a line 2 feet below the normal operating water surface elevation in that structure.
- B. Bars: Reinforcement or reinforcing bars as specified in this Section.
- C. Evaluation Report: Report prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.
- D. Give away bars: Reinforcing bars that are not required by the Contract Documents, but are installed by the Contractor to provide support for the required reinforcing bars.
- E. Wire supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

## 1.04 SYSTEM DESCRIPTION

- A. The drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

## 1.05 SUBMITTALS

- A. General:
  - 1. Submit in accordance with Section 01330 - Submittal Procedures.
  - 2. Changes to reinforcement in Contract Documents:
    - a. Indicate in a separate letter submitted with shop drawings any changes to reinforcement indicated on the Drawings or specified.
    - b. Such changes will not be acceptable unless Engineer has accepted them in writing.
- B. Product data:
  - 1. Bar supports:
    - a. Wire bar supports:
      - 1) Schedule of support materials to be provided and locations of use.
    - b. Precast concrete bar supports ("dobies"):
      - 1) Manufacturer's data indicating compression strength of concrete and confirming dimensions and thickness(es), height(s) to be provided for each location where used.



2. Mechanical reinforcing bar couplers. For each type and/or series to be provided:
  - a. Evaluation Report documenting compliance with the requirements of ICC-ES AC133.
  - b. Details, properties, and dimensions of couplers. Include type or size identification, and bar size(s) and grade(s) for which the coupler is suitable.
  - c. Manufacturer's installation and testing instructions.
  - d. Manufacturer's statement that products installed in accordance with manufacturer's recommended procedures will develop strengths and limit slip as specified in this Section.
- C. Shop drawings:
  1. Reinforcement shop drawings:
    - a. Submit drawings showing bending and placement of reinforcement required by the Contract Documents.
    - b. Clearly indicate structures or portions of structures covered by each submittal.
      - 1) Submit reinforcement shop drawings for each structure as a complete package. Submittals addressing only a portion of a structure will be rejected and returned without review, unless such presentation is accepted by Engineer in advance.
    - c. Shop drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and ACI SP-66.
    - d. Use the same bar identification marks on bending detail drawings, placement drawings, and shipping tags.
    - e. Submittals consisting solely of reinforcing bar schedules, without accompanying placement drawings, will not be accepted unless accepted under prior written agreement with Engineer.
  2. Reinforcement placement drawings:
    - a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.
    - b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
    - c. Show splice locations.
    - d. Indicate locations of mechanical reinforcing couplers if used.
    - e.
  3. Reinforcement fabrication drawings:
    - a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.  
Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.
- D. Samples (when requested by Engineer):
  1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
  2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.



- E. Test reports:
  - 1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
    - a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
    - b. In such cases, submit certificates under the shop drawing submittal number with the letter "R" (for record date) appended to the end (e.g., of the reinforcement was submitted as 03200-002-1, deliver the associated mill certificate as submittal 03200-002-1R).
  - 2. Mechanical reinforcing bar couplers:
    - a. Current Evaluation Report confirming that couplers provide specified tension and compression strength and conform to specified limits on total slip within the coupler.
    - b. Certified copy of mill tests for heat(s) of steel incorporated into the reinforcing bar couplers shipped.
    - c. For threaded sleeve type couplers, heat treatment lot numbers for each shipment.
- F. Manufacturer's instructions:
  - 1. Mechanical reinforcing bar couplers:
    - a. Manufacturer's installation instructions.
    - b. Manufacturer's instructions for confirmation testing of couplers after reinforcing bars have been inserted into the couplers.
- G. Special procedures:
  - 1. Welding procedures conforming to AWS D1.4 for reinforcement to be field welded.
    - a. Procedures qualification record.
- H. Qualifications statements:
  - 1. Welder qualifications.
- I. Closeout documents:
  - 1. Field quality control and inspection reports.
  - 2. Field quality assurance special inspection and testing reports.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Packing and shipping:
  - 1. Deliver bars bundled and tagged with identifying tags.
- B. Acceptance at site:
  - 1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

## **1.07 SEQUENCING AND SCHEDULING**

- A. Bar supports:
  - 1. Do not place concrete until samples and product data for bar supports have been accepted by Engineer.



## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. Reinforcing bars:
  - 1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
  - 2. Reinforcing bars:
    - a. ASTM A615 Grade 60 deformed bars, including the following requirements.
      - 1) Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
      - 2) Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.
- B. Thread bars:
  - 1. Reinforcing bars conforming to ASTM A615, Grade 60 unless otherwise indicated on the Drawings, and having a continuous rolled-in pattern of thread-like deformations along entire length.
    - a. Substitution of shop-cut threads on regular ASTM A615 or A706 reinforcing bars is not permitted.
  - 2. Thread bar hardware, including nuts (hex and jamb), couplers, and washers (flat, spherical, and beveled):
    - a. Provided by same manufacturer as the threaded bars.
    - b. Capable of developing a load equal to at least 125 percent of the yield strength of the threaded bar.
  - 3. Manufacturers: One of the following or equal:
    - a. DYWIDAG-Systems International (DSI), DYWIDAG Threadbar®:
      - 1) Bar and accessories hot-dip galvanized in accordance with ASTM A123.
    - b. Williams Form Engineering Corp., Grade 75 all-thread rebar:
      - 1) Bar and accessories hot-dip galvanized in accordance with ASTM A153 to minimum 3 mils coating thickness.
- C. Bar supports:
  - 1. Wire supports:
    - a. All stainless steel bar supports:
      - 1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire conforming to ASTM A493, AISI Type 316.
    - b. Stainless steel protected bar supports:
      - 1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold--drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
      - 2) Stainless steel wire ends shall conform to ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
    - c. Bright basic wire bar supports.
      - 1) Conforming to CRSI Manual if Standard Practice, Class 3.



2. Plastic supports:
    - a. Manufacturers: The following or equal:
      - 1) Aztec Concrete Accessories.
  3. Deformed steel reinforcing bar supports:
    - a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
  4. Precast concrete bar supports ("dobies"):
    - a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
    - b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
    - c. Block dimensions:
      - 1) Height to provide specified concrete cover.
      - 2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.
  5. Stainless steel wire supports on stainless steel plates:
    - a. Type 304 stainless steel wire bar support chairs or bolsters supported on Type 304 stainless steel plates resting on the ground surface.
      - 1) Weld plates to at least 2 legs of wire support chairs.
- D. Tie wires:
1. General use: Black annealed steel wire, 16-gauge or heavier.
- E. Welded wire fabric reinforcement:
1. Material:
    - a. Carbon steel conforming to ASTM A1064.
  2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
  3. Fabric may be used in place of reinforcing bars if accepted by Engineer:
    - a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.
- F. Mechanical reinforcing bar couplers :
1. General:
    - a. Only products conforming to the requirements of ACI 318 for mechanical splices, and holding a current Evaluation Report that documents the following performance characteristics, will be considered for use.
    - b. Strength of coupler: Capable of developing tension and compression strength not lower than the lesser of the following:
      - 1) ACI 318 "Type 2" units: In static tension and compression:
        - a) Minimum 125 percent of the ASTM-specified minimum yield strength of the reinforcement being spliced or terminated.
        - b) Minimum 100 percent of the ASTM-specified minimum ultimate strength of the reinforcement being spliced or terminated.



- c. Slip of reinforcing bars within coupler: Total slip of the reinforcing bars within the splice sleeve limited as follows:
  - 1) For bar sizes #14 and smaller, elongation between gauge points measured clear of the splice sleeve not exceeding 0.010 inches after coupler has been loaded to a tension of 30,000 pounds per square inch and load relaxed to a tension of 3,000 pounds per square inch.
- d. Fabrication:
  - 1) Threaded joints:
    - a) Provide threaded ends designed so that cross-threading of bars will not occur during assembly.
    - b) Fabricate male ends for female couplers using coupler manufacturer's bar threading equipment to ensure proper taper and thread engagement.
  - 2) Mark each sleeve with heat treatment lot number.
- 2. Couplers: Threaded - Reinforcing bar splice at construction joints.
  - a. Steel sleeve butt splice with tapered internal threads in forged or swaged head, and nailing flange for attaching to forms. Provide with matching, tapered male-threaded dowels for insertion and tightening into threaded sleeve after form removal.
    - 1) Provide sleeve with factory-installed plugs to prevent concrete mortar from entering internally threaded coupler.
    - 2) Provide optional clipped nailing flanges as required to maintain minimum specified concrete cover over all surfaces of coupler.
  - b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
  - c. Manufacturers: One of the following or equal:
    - 1) Dayton Superior, DBDI Splice System.
    - 2) ERICO-Pentair, Lenton Form Saver.
- 3. Couplers: Threaded - reinforcing bar splice:
  - a. Steel sleeve butt splice with tapered internal threads at each end for joining to matching tapered male threads on reinforcing bars.
  - b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
  - c. Manufacturers: One of the following, or equal:
    - 1) Dayton Superior: Taper-Lock System.
    - 2) ERICO-Pentair: Lenton Taper Threaded Splicing System.
    - 3)
- 4. Couplers: Threaded - All thread rod to reinforcing bar:
  - a. Steel sleeve butt splice with tapered internal threads on one end for joining to matching tapered male threads on reinforcing bars, and straight internal threads at opposite end for joining to matching straight male threads on all-thread rods.
  - b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
  - c. Manufacturers: The following or equal:
    - 1) ERICO-Pentair, Lenton Bolt Coupler - S4 or S5 Series.

## 2.02 FABRICATION

- A. Shop fabrication and assembly:
  - 1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.





2. Bend bars cold. Use bending collars to develop the recommended bend radius.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.
5. Bars to be fitted with mechanical couplers:
  - a. Fabricate threaded ends for connections in shop using manufacturer's recommended tools. Field fabrication is not allowed.
  - b. Cut ends square.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions:
  1. Reinforcing bars and welded wire reinforcement:
    - a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.
  2. Welded wire fabric:
    - a. Verify that sheets are not curled or kinked before or after installation.

### **3.02 PREPARATION**

- A. Surface preparation:
  1. Reinforcing bars - uncoated:
    - a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
    - b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.
    - c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

### **3.03 INSTALLATION**

- A. Reinforcing bars: General:
  1. Field-cutting of reinforcing bars is not permitted.
  2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.
- B. Placing reinforcing bars:
  1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
  2. Tolerances for placement and minimum concrete cover: As listed in Table 1.



**Table 1 - Reinforcement Placing Tolerances**

<b>Member</b>	<b>Tolerance on Reinforcement Location <sup>(1)</sup></b>	<b>Tolerance on Minimum Concrete Cover <sup>(1,2)</sup></b>
Slabs, beams, walls and columns except as noted below:		
10 inches thick and less	$\pm 3/8$ inch	- 3/8 inch
More than 10 inches thick	$\pm 1/2$ inch	- 1/2 inch
Formed soffits:	As noted above	- 1/4 inch
Longitudinal location of bends and ends of reinforcement:		
Conditions not listed below:	$\pm 2$ inches	- 1/2 inch
At discontinuous ends of brackets and corbels	$\pm 1/2$ inch	- 1/4 inch
At discontinuous ends of other members:	$\pm 1$ inch	- 1/2 inch
Notes: (1) $\pm$ indicates "plus or minus;" - indicates "minus;" + indicates "plus." (2) Tolerance on cover is limited as noted, but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.		

3. Spacing between bars:

- a. Minimum clear spacing between bars in a layer:
  - 1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
- b. Minimum clear spacing between bars in 2 or more parallel layers:
  - 1) Place bars in upper layers directly above bars in lower layers.
  - 2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
- c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.

4. Lap splices for bars:

- a. Lap splice locations and lap splice lengths: as indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.
- b. Unless otherwise specifically indicated on the Drawings (and noted as "non-contact lap splice"), install bars at lap splices in contact with each other and fasten together with tie wire.
- c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
- d. Stagger lap splices where indicated on the Drawings.
- e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.



C. Reinforcing supports:

1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
  - a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.
2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
3. Do not use "give away bars" that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.
4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

Table 2 - Reinforcement Support Materials		
Case	Location	Material
a.	Concrete placed over earth and concrete seal slabs ("mud mats"):	Precast concrete bar supports or Stainless steel wire supports on stainless steel plates.
b.	Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings):	All stainless steel bar supports.
c.	Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work	All stainless steel bar supports.
d.	Concrete placed against forms and exposed to interior equipment/piping areas in the finished work	All stainless steel bar supports.
e.	Between mats of reinforcement, and fully embedded within a concrete member	Bright basic wire bars supports, or deformed steel reinforcing bars.

D. Tying of reinforcing:

1. Fasten reinforcement securely in place with wire ties.
2. Tie reinforcement at spacings sufficient to prevent shifting.
  - a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
3. Tie slab bars at every intersection around perimeter of slab.
4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:



**Table 3 - Maximum Spacing of Tie Wires for Reinforcement**

<b>Bar Size</b>	<b>Slab Bar Spacing (inches)</b>	<b>Wall Bar Spacing (inches)</b>
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

5. After tying:
  - a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
  - b. Remove tie wire clippings from inside forms before placing concrete.
- E. Welded wire fabric reinforcement:
  1. Install only where indicated on the Drawings or accepted in advance by Engineer.
  2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
  3. Straighten welded wire fabric to make sheets flat in the Work.
  4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
    - a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to Engineer.
  5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
  6. Lap splice welded wire fabric as indicated on the Drawings.
    - a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.
- F. Welding reinforcing bars:
  1. Weld reinforcing bars only where indicated on the Drawings or where acceptance is received from Engineer prior to welding.
  2. Perform welding in accordance with AWS D1.4 and welding procedures accepted by Engineer.
    - a. Conform to requirements for minimum preheat and interpass temperatures.
  3. Submit:
    - a. Welding procedures specification.
    - b. Procedures qualification record.
    - c. Welder qualification test record.
  4. Do not tack weld reinforcing bars except where specifically indicated on the Drawings.
- G. Reinforcing bar mechanical couplers:
  1. Install only at locations indicated on the Drawings or where prior approval has been obtained from Engineer.



2. Install in accordance with manufacturer's instructions and requirements of Evaluation Report.
  - a. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.
  - b. After assembly of the splice, tighten using torque load not less than that recommended by the manufacturer.
3. Unless greater cover is indicated on the Drawings, provide clear cover from surface of concrete to outside face of couplers that is not less than the minimum concrete cover specified for typical reinforcement.
  - a. If cover is less than required, contact Engineer for evaluation of conditions before modifying locations of bars or placing concrete.
  - b. Modifications to maintain or provide required concrete cover, such as addition of concrete; re-positioning of stirrups, ties, etc., may be completed only after approval by Engineer.

### **3.04 FIELD QUALITY CONTROL**

- A. Provide quality control for the Work of this Section as specified in Section 01450 - Quality Control.
- B. Field inspections and testing:
  1. Submit records of inspections and testing to Engineer in electronic format within 24 hours after completion.
- C. Manufacturer's services:
  1. Furnish manufacturer's technical representative to conduct jobsite training regarding proper storage, handling, and installation of mechanical reinforcing bar couplers and bar end anchors for personnel who will perform the installation. Engineer may attend training session.

### **3.05 FIELD QUALITY ASSURANCE**

- A. Provide quality assurance as specified in Section 01450 - Quality Control.
- B. Special inspections and tests:
  1. Provide as specified in Section 01455 - Special Tests and Inspections.
  2. Frequency of inspections:
    - a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01410 - Regulatory Requirements.
  3. Preparation:
    - a. Review Drawings and Specification for the Work to be observed.
    - b. Review approved submittal and shop drawings.
  4. Inspections: Special inspection shall include, but is not limited to, the following items.
    - a. Reinforcement: General:
      - 1) Type (material) and location of reinforcement supports.
      - 2) Bar material/steel grade and bar size.
      - 3) Location, placement, and spacing of bars.
      - 4) Clear concrete cover over reinforcement.
      - 5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings.)



- 6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
- 7) Reinforcement tied in position and tie wire legs turned inward toward the center of the concrete section.
- b. Reinforcement: Welding:
  - 1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
  - 2) Provide periodic inspection for:
    - a) Weldability of reinforcement other than ASTM A706.
    - b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
  - 3) Provide continuous inspection for:
    - a) Other welds.
    - b) Welds at mechanical reinforcing bar couplers and end anchors.
  - 4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
5. Mechanical reinforcing bar couplers:
  - a. Special inspection shall include, but is not limited to, the following items:
    - 1) Coupler model and identification.
    - 2) Couplers are installed in accordance with the requirements of the Engineering Report for each product.
    - 3) Confirmation of the following:
      - a) Grade and size of reinforcing bars.
      - b) Position of couplers and end anchors.
      - c) Insertion length of reinforcement.
      - d) Tightening of bars in the couplers and end anchors.
6. Records of inspections:
  - a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
  - b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspections.

### **3.06 NON-CONFORMING WORK**

- A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION







## SECTION 03300

### CAST-IN-PLACE CONCRETE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Cast-in-place concrete.

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
1. 305 - Hot Weather Concreting Standard.
  2. 306 - Cold Weather Concreting Standard.
  3. 318 - Building Code Requirements for Structural Concrete and Commentary.
  4. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
  5. Manual of Concrete Practice.
- B. ASTM International (ASTM):
1. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
  2. C33 - Standard Specification for Concrete Aggregates.
  3. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
  4. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
  5. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
  6. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
  7. C94 - Standard Specification for Ready-Mixed Concrete.
  8. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
  9. C117 - Standard Test Method for Materials Finer than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing.
  10. C123 - Standard Test Method for Lightweight Particles in Aggregate.
  11. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
  12. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
  13. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
  14. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
  15. C150 - Standard Specification for Portland Cement.
  16. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
  17. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
  18. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
  19. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.



20. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
21. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
22. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
23. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
24. C494 - Standard Specification for Chemical Admixtures for Concrete.
25. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
26. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
27. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
28. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
29. D75 - Standard Practice for Sampling Aggregates.
30. D2103 - Standard Specification for Polyethylene Film and Sheeting.

C. NSF International (NSF):

1. 61 - Drinking Water System Components - Health Effects.

### 1.03 DEFINITIONS

- A. Alkali: Sum of sodium oxide and potassium oxide calculated as sodium oxide.
- B. Cementitious materials: Portland cement and fly ash.
- C. Cold weather: A period when for more than 3 consecutive days, the average daily outdoor temperature drops below 40 degrees Fahrenheit. The average daily temperature is the average of the highest and lowest temperatures during the period from midnight to midnight. When temperatures above 50 degrees Fahrenheit occur during more than half of any 24-hour duration, the period shall no longer be regarded as cold weather.
- D. Cold weather concreting: Operations for placing, finishing, curing, and protection of concrete during cold weather.
- E. Green concrete: Concrete with less than 100 percent of the specified strength.
- F. Hairline crack: Crack with a crack width of less than 4 thousandths of an inch.
- G. Hot weather: A period when project conditions such as low humidity, high temperature, solar radiation, and high winds, promote rapid drying of freshly placed concrete.
- H. Hot weather concreting: Operations for placing, finishing, curing, and protection of concrete during hot weather.



## 1.04 SYSTEM DESCRIPTION

### A. Performance requirements:

#### 1. General:

- a. Except as otherwise specified, provide concrete composed of portland cement, fly ash, fine aggregate, coarse aggregate, admixtures and water so proportioned and mixed as to produce plastic, workable mixture in accordance with requirements as specified in this Section and suitable to specific conditions of placement.
- b. Proportion materials in a manner that will secure lowest water-cementitious materials ratio that is consistent with good workability, plastic and cohesive mixture, and a mixture that is within specified slump range.
- c. Proportion fine and coarse aggregates in manner such as not to produce harshness in placing or honeycombing.

#### 2. It is the intent of this Section to secure for every part of the Work concrete with homogeneous mixture, which when hardened will have required strength, watertightness, and durability:

- a. It is recognized that some surface hairline cracks and crazing will develop in the concrete surfaces.
- b. Construction, contraction, and expansion joints have been specified and positioned in structures as indicated on the Drawings, and curing methods specified, for purpose of reducing number and size of cracks, due to normal expansion and contraction expected from specified concrete mixes.
- c. Repair cracks which develop in walls or slabs and repair cracks which show any signs of leakage until all leakage is stopped.
- d. Pressure inject visible cracks, other than hairline cracks and crazing, in following areas with epoxy as specified in Section 03931 - Epoxy Injection System:
  - 1) Floors and walls of water bearing structures.
  - 2) Walls and overhead slabs of passageways or occupied spaces, outsides of which are exposed to weather or may be washed down and are not specified to receive separate waterproof membrane.
  - 3) Other items not specified to receive separate waterproof membrane: Slabs over water channels, wet wells, reservoirs, and other similar surfaces.
- e. Walls or slabs, as specified above, that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy: Seal on water or weather side by coatings of surface sealant system, as specified in this Section.
- f. Pressure injection and sealing: Continue as specified above until structure is watertight and remains watertight for not less than 1 year after final acceptance or date of final repair, whichever occurs later in time.

#### 3. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI 318, ACI 350, Manual of Concrete Practices, and recommended practices.



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## SUBMITTALS

- A. Cement mill tests:
  - 1. Include alkali content representative of each shipment of cement for verification of compliance with specified requirements.
  - 2. Provide mill test reports dated not more than 90 days before the date of submittal.
- B. Cold weather concreting:
  - 1. Procedures for the production, transportation, placement, protection, curing, and temperature monitoring for concrete during cold weather.
  - 2. Procedures to be implemented upon abrupt changes in weather conditions or equipment failures.
- C. Concrete mixes: Full details, including mix design calculations for concrete mixes proposed for use for each class of concrete:
  - 1. Include information on correction of batching for varying moisture contents of fine aggregate.
  - 2. Source quality test records with mix design submittal:
    - a. Include calculations for required compressive strength ( $f'_{cr}$ ) based on source quality test records.
- D. Concrete aggregate tests: Certified copies in triplicate of commercial laboratory tests not more than 90 days old of all samples of concrete aggregates:
  - 1. Coarse aggregate:
    - a. Abrasion loss.
    - b. Clay lumps and friable particles.
    - c. Coal and lignite.
    - d. Materials finer than 200 sieve.
    - e. Reactivity.
    - f. Shale and chert.
    - g. Soundness.
  - 2. Fine aggregate:
    - a. Clay lumps.
    - b. Color.
    - c. Decantation.
    - d. Reactivity.
    - e. Shale and chert.
    - f. Soundness.
- E. Drying shrinkage test data.
- F. Fine or coarse aggregate batched from more than 1 bin: Analyses for each bin, and composite analysis made up from these, using proportions of materials to be used in mix.
- G. Fly ash Certificate of Compliance: Identify source of fly ash and certify compliance in accordance with ASTM C618.
- H. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Corrective measures for use prior to placing concrete.



- I. Hot weather concreting: Procedures for production, placement, finishing, curing, protection, and temperature monitoring for concrete during hot weather and appropriate corrective measures.
- J. Heating equipment for cold weather concreting: Information on type of equipment used for heating materials and new concrete in process of curing during excessively cold weather.
- K. Information on mixing equipment.
- L. Product data: Submit data completely describing products.
- M. Sequence of concrete placing: Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements.
- N. Sieve analysis: Submit sieve analyses of fine and coarse aggregates being used in triplicate at least every 3 weeks and at any time there is significant change in grading of materials.
- O. Trial batch test data:
  - 1. Submit data for each test cylinder.
  - 2. Submit data that identifies mix and slump for each test cylinder.
- P. Weather monitoring: Records of:
  - 1. Relative humidity.
  - 2. Site ambient temperature.
  - 3. Wind speed.
- Q. Temperature of freshly placed concrete.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Packing and shipping:
  - 1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
  - 2. Deliver and store packaged materials in original containers until ready for use.
  - 3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.
- B. Acceptance at site: Reject material containers or materials showing evidence of water or other damage.

#### **1.07 PROJECT CONDITIONS**

- A. Environmental requirements:
  - 1. Monitoring weather conditions:
    - a. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.





- b. Measure and record temperature of fresh concrete. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature of concrete.
- c. Monitor and keep records of the weather forecast starting at least 48 hours prior to placing concrete in order to allow enough time for taking appropriate measures pertaining to Hot or Cold weather concreting.
- 2. Hot weather concreting:
  - a. Initiate evaporation control measures when concrete and air temperatures, relative humidity of the air, and the wind velocity have the capacity to evaporate water from a free surface at a rate that is equal to or greater than 0.2 pounds per square feet per hour. Determine evaporation rate using the Menzel Formula and monograph in ACI 305 3.1.3.
  - b. When ambient air temperature is above 85 degrees Fahrenheit: Prior to placing concrete, cool forms and reinforcing steel by water cooling to below 90 degrees Fahrenheit.
  - c. Monitor weather conditions at the site including air temperature, humidity, and wind speed, to assess the need for evaporation control measures begin monitoring site conditions no later than 1 hour before the start of concrete placement. Continue to monitor site conditions at intervals of 30 minutes until concrete curing has begun.
  - d. Temperature of concrete mix at time of placement: Keep temperature below 90 degrees Fahrenheit by methods which do not impair quality of concrete.
  - e. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Take corrective measures to minimize rapid water loss from concrete:
  - f. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature around concrete.
- 3. Cold weather concreting:
  - a. Concrete placed below ambient air temperature of 45 degrees Fahrenheit and falling or below 40 degrees Fahrenheit:
    - 1) Make provision for heating water.
  - b. Follow recommendations of ACI 306 for preparation, placement, and protection of concrete during cold weather.
  - c. If materials have been exposed to freezing temperatures to degree that any material is below 35 degrees Fahrenheit: Heat such materials.
  - d. Heating water, cement, or aggregate materials:
    - 1) Do not heat in excess of 160 degrees Fahrenheit.
  - e. Protection of concrete in forms:
    - 1) Do not remove forms from concrete when outside ambient air temperature is below 50 degrees Fahrenheit until concrete has attained its minimum specified compressive strength. Evidence of strength shall be based on by testing of cylinders stored in the field under equivalent conditions to those at the concrete structure.
    - 2) Protect by means of covering with tarpaulins, or other acceptable covering acceptable to Engineer.
    - 3) Provide means for circulating warm moist air around forms in manner to maintain temperature of 50 degrees Fahrenheit for at least 5 days.



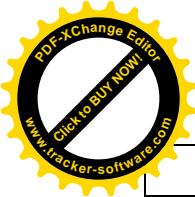
## 1.08 SEQUENCING AND SCHEDULING

- A. Schedule placing of concrete in such manner as to complete any single placing operation to construction or expansion joint.

## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. Admixtures:
  - 1. General:
    - a. Do not use admixtures of any type, except as specified, unless written acceptance has been obtained from the Engineer.
    - b. Admixtures shall be compatible with concrete and other admixtures. Admixtures other than pozzolans shall be the products of a single manufacture to ensure compatibility.
    - c. Do not use admixtures containing chlorides calculated as chloride ion in excess of 0.5 percent by weight of cement.
    - d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
  - 2. Air entraining admixture:
    - a. Provide concrete with 5 percent, within 1 percent, entrained air of evenly dispersed air bubbles at time of placement.
    - b. In accordance with ASTM C260.
  - 3. Water reducing admixture:
    - a. May be used at the Contractor's option.
    - b. In accordance with ASTM C494, Type A or Type D.
    - c. Not contain air-entraining agents.
    - d. Liquid form before adding to the concrete mix.
    - e. No decrease in cement is permitted as result of use of water reducing admixture.
  - 4. Super-plasticizers: Are not to be used without acceptance by Engineer.
- B. Aggregate:
  - 1. General:
    - a. Provide concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of allowable amounts specified.
    - b. Grade aggregate in accordance with ASTM C136 and D75.
    - c. Provide unit weight of fine and coarse aggregate that produces in place concrete with weight of not less than 140 pounds per cubic foot.
    - d. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
  - 2. Fine aggregate:
    - a. Provide fine aggregate for concrete or mortar consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
    - b. Do not provide aggregate having deleterious substances in excess of following percentages by weight of contaminating substances.
      - 1) In no case shall total exceed percent listed.



<u>Item</u>	<u>Test Method</u>	<u>Percent</u>
Removed by decantation (dirt, silt, etc.)	ASTM C117	3
Shale or Chert	ASTM C123 ASTM C295*	1 1
Clay Lumps	ASTM C142	1
* Test Method C123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C295 is used to identify which of the lightweight particles are shale or chert. If the results of Test Method C123 are less than 1 percent, Test Method C295 is not required.		

- c. Except as otherwise specified, grade fine aggregate from coarse to fine in accordance with ASTM C33.
3. Coarse aggregate:
  - a. Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances.
  - b. Not exceeding 15 percent by weight, of thin or elongated pieces having length greater than 5 times average thickness.
  - c. Deleterious substances: Not in excess of following percentages by weight, and in no case having total of all deleterious substances exceeding 2 percent.

<u>Item</u>	<u>Test Method</u>	<u>Percent</u>
Shale or chert	ASTM C123 ASTM C295*	1.25 1
Coal and lignite	ASTM C123	1/4
Clay lumps and friable particles	ASTM C142	1/4
Materials finer than Number 200 sieve	ASTM C117	1/2**
* Test Method C123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C295 is used to identify which of the lightweight particles are shale, chert, coal, or lignite. If the results of Test Method C123 are less than 1.25 percent (the minimum combined percentage of shale, chert, coal and lignite), Test Method C295 is not required.		
** Except when material finer than Number 200 sieve consists of crusher dust, maximum amount shall be 1 percent.		

- d. Grading:
  - 1) Aggregate for Class A, B, C, and D concrete: In accordance with ASTM C33, Size Number 57, except as otherwise specified or authorized in writing by the Engineer.
  - 2) Aggregate for Class CE concrete for encasement of electrical conduits:
    - a) Graded in accordance with ASTM C33, Size Number 8.



- C. Concrete sealer:
  - 1. Manufacturers: One of the following or equal:
    - a. Euclid Chemical Co., Diamond Hard.
    - b. L&M Construction Chemicals, SealHard.
- D. Conduit encasement coloring agent:
  - 1. Color: Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
  - 2. Manufacturers: One of the following or equal:
    - a. Davis Co., #160 Brick Red.
    - b. Euclid Chemical Co., Increte Division, "Colorcrete Brick Red."
  - 3. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.
- E. Evaporation retardant:
  - 1. Manufacturers: One of the following or equal:
    - a. BASF, MasterKure ER 50.
    - b. Euclid Chemical Co., Eucobar.
- F. Fly ash:
  - 1. Fly ash in accordance with ASTM C618, Class F, may be used in concrete made with Type II portland cement.
  - 2. Maximum of 15 percent by weight of fly ash to total weight of cementitious materials.
    - a. The total weight of cementitious materials shall not be less than minimum cementitious materials listed in Table A.
  - 3. Do not use in concrete made with portland-pozzolan cement.
  - 4. Loss on ignition: Not exceed 4 percent.
- G. Keyway material: Steel, plastic, or lumber.
- H. Nonslip abrasive:
  - 1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
  - 2. Manufacturers: One of the following or equal:
    - a. Abrasive Materials, Inc.
    - b. Euclid Chemical Co., Flexolith Summer Grade.
- I. Portland cement:
  - 1. Conform to specifications and tests in accordance with ASTM C150, Types II or III, low alkali, except as specified otherwise.
  - 2. Have total alkali containing not more than 0.60 percent.
  - 3. Exposed concrete in any individual structure: Use only one brand of portland cement.
  - 4. Cement for finishes or repairs: Provide cement from same source and of same type as concrete to be finished or repaired.
- J. Sheet membrane for curing:
  - 1. Polyethylene film:
    - a. In accordance with ASTM C171.
    - b. Color: White.



- c. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
  - d. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.
- K. Sprayed membrane curing compound: Clear type with fugitive dye in accordance with ASTM C309, Type 1D.
- L. Surface sealant system:
  - 1. Manufacturers: One of the following or equal:
    - a. Euclid Chemical Co., Vandex Super.
    - b. Kryton International, Inc., Krystol T1.
    - c. Xypex Chemical Corp., Xypex Concentrate.
- M. Water:
  - 1. Water for concrete, washing aggregate, and curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
  - 2. Chlorides and sulfate ions:
    - a. Water for conventional reinforced concrete: Use water containing not more than 1,000 milligrams per liter of chlorides calculated as chloride ion, nor more than 1,000 milligrams per liter of sulfates calculated as sulfate ion.
    - b. Water for prestressed or post-tensioned concrete: Use water containing not more than 650 milligrams per liter of chlorides calculated as chloride ion, or more than 800 milligrams per liter of sulfates calculated as sulfate ion.

## **2.02 EQUIPMENT**

- A. Mixing concrete:
  - 1. Mixers may be of stationary plant, paver, or truck mixer type.
  - 2. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material.
  - 3. Mixing equipment:
    - a. Capable of combining aggregates, cementitious materials, and water within specified time into thoroughly mixed and uniform mass and discharging mixture without segregation.
    - b. Maintain concrete mixing plant and equipment in good working order and operated at loads, speeds, and timing recommended by manufacturer or as specified.
    - c. Proportion cementitious materials and aggregate by weight.
- B. Machine mixing:
  - 1. Batch plant shall be capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.
  - 2. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.



3. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
  4. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
  5. Retempering of concrete will not be permitted.
  6. Discharge entire batch before recharging.
  7. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
  8. Mixers:
    - a. Perform mixing in batch mixers of acceptable type.
    - b. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
    - c. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
      - 1) Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
- C. Transit-mixed concrete:
1. Mix and deliver in accordance with ASTM C94.
  2. Total elapsed time between addition of water at batch plant and discharging completed mix:
    - a. Not to exceed 90 minutes.
    - b. Elapsed time at project site shall not exceed 30 minutes.
  3. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
  4. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.
  5. Continuously revolve drum after it is once started until it has completely discharged its batch:
    - a. Do not add water until drum has started revolving.
    - b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. The Contractor will not be entitled to additional compensation because of such increase or decrease.
- D. Other types of mixers: In case of other types of mixers, mixing shall be as follows:
1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
  2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
  3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.



**MIXES****A. Measurements of materials:**

1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
5. Weighing cementitious materials:
  - a. Weigh cementitious materials separately.
  - b. Cement in unbroken standard packages (sacks): Need not be weighed.
  - c. Weigh bulk cementitious materials and fractional packages.
6. Measure mixing water by volume or by weight.

**B. Concrete proportions and consistency:**

1. Provide concrete that can be worked readily into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on surface.
2. Prevent unnecessary or haphazard changes in consistency of concrete.
3. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete Classes, with exception of Class CE.
4. Aggregate:
  - a. Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operation.
5. Maximum concrete mix water to cementitious materials ratio, minimum cementitious materials content, and slump range: Conform to values specified in Table A in this Section.
6. Concrete batch weights: Control and adjust to secure maximum yield. At all times, maintain proportions of concrete mix within specified limits.
7. Mix modification: If required, by the Engineer, modify mixture within limits set forth in this Section.

**C. Concrete mixes:**

1. Proportioning of concrete mix: Proportion mixes based on required compressive strength  $f'_{cr}$ .
2. Mixes:
  - a. Adjusting of water: After acceptance, do not change mixes without acceptance by Engineer, except that at all times adjust batching of water to compensate for free moisture content of fine aggregate.
  - b. Total water content of each concrete class: Not exceed those specified in Table A in this Section.
  - c. Checking moisture content of fine aggregate: Furnish satisfactory means at batching plant for checking moisture content of fine aggregate.
3. Change in mixes: Submit new mix design and perform new trial batch and test program as specified in this Section.





D. Classes of concrete:

1. Provide concrete consisting of 5 classes: Classes A, B, C, D, and CE. Use where specified or indicated on the Drawings.
2. Weight of concrete classes: Provide classes of concrete having minimum weight of 145 pounds per cubic foot.
3. Class B concrete: Class B concrete may be substituted for Class A concrete, when high-early strength concrete is needed in areas specifically accepted by the Engineer and that do not require sulfate resistant concrete.
4. Class C concrete: Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
5. Class D concrete: Use Class D for precast concrete items.
6. Class CE concrete: Use Class CE for electrical conduit encasements.
7. All other concrete, unless specified or otherwise indicated on the Drawings: Use Class A concrete.
8. Pumped concrete: Provide pumped concrete that complies with all requirements of this Section.
9. Do not place concrete with slump outside limits indicated in Table A.
10. Classes:
  - a. Classes A, C, D, and CE concrete: Make with Type II low alkali portland cement.
  - b. Class B concrete: Make with Type III low alkali portland cement.
  - c. Admixtures: Provide admixtures as specified in this Section.

E. Air entraining admixture:

1. Add agent to batch in portion of mixing water.
2. Batch solution by means of mechanical batcher capable of accurate measurement.

## 2.04 SOURCE QUALITY CONTROL

A. Tests:

1. Trial batches:
  - a. After concrete mix designs have been accepted by Engineer, have trial batches of the accepted Class A, Class B, and Class D concrete mix designs prepared by testing laboratory acceptable to the Engineer.
  - b. Prepare trial batches using cementitious materials and aggregates proposed to be used for the Work.
  - c. Prepare trial batches with sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient test cylinders.
  - d. Test cylinders: Provide cylinders having 6-inch diameter by 12-inch length and that are prepared in accordance with ASTM C31 for tests specified in this Section.
  - e. Determine slump in accordance with ASTM C143.
  - f. Test cylinders from trial batch:
    - 1) Test 8 cylinders for compressive strength in accordance with ASTM C39:
      - a) Test 4 cylinders at 7 days and 4 at 28 days.



- b) Establish ratio between 7 day and 28 day strength for mix. 7-day strength may be taken as satisfactory indication of 28-day strength provided effects on concrete of temperature and humidity between 7 day and 28 day are taken into account.
    - 2) Average compressive strength of 4 test cylinders tested at 28 days: Equal to or greater than required average compressive strength ( $f'_{cr}$ ) on which concrete mix design is based.
  - g. If trial batch tests do not meet specified requirements for slump, strength, workability, consistency, drying shrinkage, and finishing, change concrete mix design proportions and, if necessary, source of aggregate.
    - 1) Perform additional trial batches and tests until an acceptable trial batch is produced that meets requirements of this Section.
  - h. Perform test batches and tests required to establish trial batches and acceptability of materials without change in Contract Price.
  - i. Do not place concrete until the concrete mix design and trial batch have been accepted by Engineer.
2. Required average compressive strength:
- a. Determine required average compressive strength ( $f'_{cr}$ ) for selection of concrete proportions for mix design, for each class of concrete, using calculated standard deviation for its corresponding specified compressive strength ( $f'_c$ ) in accordance with ACI 318 and ACI 350.
  - b. When test records of at least 30 consecutive tests that span period of not less than 45 calendar days are available, establish standard deviation as in accordance with ACI 318 and ACI 350 and as modified in this Section.
  - c. Provide test records from which to calculate standard deviation that represent materials, quality control procedures, and conditions similar to materials, quality control procedures, and conditions expected to apply in preparation of concrete for the Work.
  - d. Provide test records with materials and proportions that are more restricted than those for the Work.
  - e. Specified compressive strength ( $f'_c$ ) of concrete used in test records: Within 1,000 pounds per square inch of that specified for the Work.
  - f. When lacking adequate test records for calculation of standard deviation meeting requirements, determine required average compressive strength  $f'_{cr}$  from following Table B.

<b>TABLE B</b>	
<b>REQUIRED AVERAGE COMPRESSION STRENGTH</b>	
<b>Specified Compressive Strength <math>f'_c</math> (pounds per square inch)</b>	<b>Required Average Compressive Strength <math>f'_{cr}</math> (pounds per square inch)</b>
Less than 3,000	$f'_c + 1,000$
3,000 to 5,000	$f'_c + 1,200$
Over 5,000	$1.10f'_c + 700$

3. Aggregate:
- a. Testing of concrete aggregate is at Contractor's expense.
  - b. Provide test reports representing samples of materials taken and tested at the following times:
    - 1) Not more than 60 days prior to the date on the proposed materials for concrete mixes.



- 2) Not more than 60 days prior to any change in the source of aggregates, including suppliers and/or quarries.
- 3) Whenever there is a significant change in aggregate quality or gradation from a previously submitted and accepted source.
- c. Sample aggregate in accordance with ASTM D75.
- d. Fine and coarse aggregates:
  - 1) Gradation: Test in accordance with ASTM C136. Use sieves with square openings for testing grading of aggregates.
  - 2) Alkali-silica reactivity:
    - a) Provide fine and coarse aggregate with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260 , unless the aggregate has been determined to be not deleteriously reactive based on testing in accordance with one of the following:
      - (1) ASTM C1293: Expansion not greater than 0.04 percent at 1 year.
- e. Fine aggregate:
  - 1) Provide fine aggregate that does not contain strong alkali nor organic matter which gives color darker than standard color when tested in accordance with ASTM C40.
  - 2) Provide aggregate having soundness in accordance with ASTM C33 when tested in accordance with ASTM C88.
- f. Coarse aggregate:
  - 1) Soundness when tested in accordance with ASTM C88: Have loss not greater than 10 percent when tested with sodium sulfate.
  - 2) Abrasion Loss: Not exceed 45 percent after 500 revolutions when tested in accordance with ASTM C131.
- g. Fly ash:
  - 1) Sampling and testing: Sample and test fly ash in accordance with ASTM C311.
- h. Portland cement:
  - 1) Determination of alkali content: In accordance with ASTM C114.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Liquid evaporation retardant:
  1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, immediately after the concrete has been screeded, coat the surface of the concrete with a liquid evaporation retardant.
  2. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks.
  3. Conditions which result in rapid evaporation of moisture may include one or more of the following:
    - a. Low humidity.
    - b. Windy conditions.
    - c. High temperature.
- B. Surface sealant system:
  1. Apply as recommended by manufacturer published instructions.



2. Where concrete continues to sweat or leak, apply additional coats of surface sealant until the sweating or leaks stop.
- C. Joints and bonding:
  1. As far as practicable construct concrete work as monolith.
  2. Locations of construction, expansion, and other joints are indicated on the Drawings or as specified in this Section.
  3. Time between placement of adjacent concrete separated by joints:
    - a. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
      - 1) Slabs.
      - 2) Walls.
    - b. Provide not less than 7 days (168 hours) between placement of upper and lower pours for the following:
      - 1) Walls over slabs.
      - 2) Slabs over walls.
      - 3) Slabs keyed into the sides of walls.
  4. Construction joints:
    - a. Where construction joints are not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
    - b. In order to preserve strength and watertightness of structures, make no other joints, except as authorized the Engineer.
    - c. At construction joints, thoroughly clean concrete of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of heavy sandblasting.
    - d. Cleaning of construction joints:
      - 1) Wash construction joints free of sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
      - 2) Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use vacuum cleaner for their removal, after which flush cleaned surfaces with water.
      - 3) Provide cleanout hole at base of each wall and column for inspection and cleaning.
    - e. At horizontal joints: As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03600 - Grouting with a thickness of not less than 1/2 inch nor more than 1 inch.
  5. Take special care to ensure that concrete is well consolidated around and against waterstops and waterstops are secured in proper position.
  6. Contraction, construction, and expansion Joints:
    - a. Constructed where and as indicated on the Drawings.
    - b. Waterstops, expansion joint material, synthetic rubber sealing compound, and other similar materials: As specified in Sections 03150 - Concrete Accessories and 07900 - Joint Sealants.
  7. Repair of concrete: Where it is necessary to repair concrete by bonding mortar or new concrete to concrete which has reached its initial set, first coat surface of set concrete with epoxy bonding agent as specified in Section 03071 - Epoxies.



- D. Conveying and placing concrete:
1. Convey concrete from mixer to place of final deposit by methods that prevent separation or loss of materials.
  2. Use equipment for chuting, pumping, and conveying concrete of such size and design as to ensure practically continuous flow of concrete at delivery end without segregation of materials.
  3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
  4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of day's placement.
- E. Placing concrete:
1. Place no concrete without prior authorization of the Engineer.
  2. Do not place concrete until:
    - a. Reinforcement is secure and properly fastened in its correct position and loose form ties at construction joints have been retightened.
    - b. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
    - c. Forms have been cleaned and oiled as specified.
  3. Do not place concrete in which initial set has occurred, or that has been retempered.
  4. Do not place concrete during rainstorms or high velocity winds.
  5. Protect concrete placed immediately before rain to prevent water from coming in contact with such concrete or winds causing excessive drying.
  6. Keep sufficient protective covering on hand at all times for protection of concrete.
  7. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested and accepted by the Engineer.
  8. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
    - a. Provide this notification in such time in advance of operations, as the Engineer deems necessary to make final inspection of preparations at location of proposed concrete placing.
    - b. Place forms, reinforcement, screeds, anchors, ties, and inserts in place before notification of readiness is given to the Engineer.
    - c. Depositing concrete:
      - 1) Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      - 2) Do not deposit concrete in large quantities in one place and work along forms with vibrator or by other methods.
      - 3) Do not drop concrete freely into place from height greater than 5 feet.
      - 4) Use tremies for placing concrete where drop is over 5 feet.
      - 5) Commence placement of concrete on slopes, starting at bottom of slope.
  9. Place concrete in approximately horizontal layers not to exceed 24 inches in depth and bring up evenly in all parts of forms.
  10. Continue concrete placement without avoidable interruption, in continuous operation, until end of placement is reached.



11. After concrete placement begins, continue concrete placement without significant interruption. Plan and implement precautions to prevent any delay, between layers being placed, from exceeding 20 minutes.
  12. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout not less than 1/2 inch in thickness nor more than 1 inch in thickness over surface before placing additional concrete.
  13. Placement of concrete for slabs, beams, or walkways:
    - a. If cast monolithically with walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
    - b. Allow set time of not less than 1 hour for shrinkage.
- F. Consolidating concrete:
1. Place concrete with aid of acceptable mechanical vibrators.
  2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the work.
  3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
  4. Vibrators:
    - a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    - b. In addition to vibrators in actual use while concrete is being placed, have on hand minimum 1 spare vibrator in serviceable condition.
    - c. Do not place concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.
  5. Take special care to place concrete solidly against forms to leave no voids.
  6. Take every precaution to make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
- G. Footings and slabs on grade:
1. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
  2. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
  3. If subgrade becomes dry prior to concrete placement, sprinkle again, without forming pools of water.
  4. Do not place concrete if subgrade is muddy or soft. Maximum deformation of the subgrade under a fully loaded ready mix truck shall not exceed 1/2 inch.
- H. Loading concrete:
1. Green concrete:
    - a. No heavy loading of green concrete will be permitted.
  2. No backfill shall be placed against concrete walls, connecting slabs, or beams until the concrete has reached the specified strength.
  3. Use construction methods, sequencing, and allow time for concrete to reach adequate strength to prevent overstress of the concrete structure during construction.





I. Curing concrete:

1. General:

- a. Cure concrete by methods specified in this Section.
- b. Keep concrete continuously moist and at a temperature of at least 50 degrees Fahrenheit for minimum of 7 days after placement.
- c. Cure concrete to be painted with water or sheet membrane.
- d. Do not use sprayed membrane curing or sealing compounds on concrete surfaces that are to receive paint or upon which any material is to be bonded.
- e. Water cure or sheet membrane cure concrete slabs that are specified to be sealed by concrete sealer.
- f. Cure other concrete by water curing or sprayed membrane curing compound at the Contractor's option.
- g. Floor slabs may be cured using sheet membrane curing.

2. Water curing:

- a. Keep surfaces of concrete being water cured constantly and visibly moist day and night for period of not less than 7 days.
- b. Each day forms remain in place count as 1 day of water curing.
- c. No further curing credit will be allowed for forms in place after contact has once been broken between concrete surface and forms.
- d. Do not loosen form ties during period when concrete is being cured by leaving forms in place.
- e. Flood top of walls with water at least 3 times per day, and keep concrete surfaces moist at all times during 7 day curing period.

3. Sprayed membrane curing compound:

- a. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
- b. If more than 1 hour elapses after removal of forms, do not use curing compound, but use water curing for full curing period.
- c. If surface requires repairing or painting, water cure such concrete surfaces.
- d. Do not remove curing compound from concrete in less than 7 days.
- e. Curing compound may be removed only upon written request by Contractor and acceptance by Engineer, stating what measures are to be performed to adequately cure concrete.
- f. Take care to apply curing compound to construction joints. Apply to all surfaces along full profile of joints.
- g. After curing period is complete, remove curing compound placed within construction joint profile by heavy sandblasting prior to placing any new concrete.
- h. Contractor's Option: Instead of using curing compound for curing of construction joints, such joints may be water cured.
- i. Apply curing compound by mechanical, power operated sprayer and mechanical agitator that will uniformly mix all pigment and compound.
- j. Apply curing compound in at least 2 coats.
- k. Apply each coat in direction 90 degrees to preceding coat.
- l. Apply curing compound in sufficient quantity so that concrete has uniform appearance and that natural color is effectively and completely concealed at time of spraying.
- m. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.





- n. Thickness and coverage of curing compound: Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
  - o. The Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and also more than is customary in the trade.
  - p. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.
  - q. If the Contractor desires to use curing compound other than specified curing compound, coat sample areas of concrete wall with proposed curing compound and also similar adjacent area with specified compound in specified manner for comparison:
    - 1) If proposed sample is not equal or better, in opinion of the Engineer, in all features, proposed substitution will not be allowed.
  - r. Prior to final acceptance of the work, remove, by sandblasting or other acceptable method, any curing compound on surfaces exposed to view, so that only natural color of finished concrete is visible uniformly over entire surface.
4. Sheet membrane curing:
- a. Install sheet membrane as soon as concrete is finished and can be walked on without damage.
  - b. Seal joints and edges with small sand berm.
  - c. Keep concrete moist under sheet membrane.
- J. Cold weather concreting:
- 1. Preparation before concreting:
    - a. Remove snow, ice, and frost from the surfaces, including reinforcement against which the concrete is to be placed.
    - b. The subgrade shall be free of frost before concrete placing begins.
    - c. Do not place concrete around any embedment that is at a temperature below freezing and is sufficiently massive as to cause the adjacent concrete to freeze.
  - 2. Placement of concrete:
    - a. Placement temperature:
      - 1) The minimum temperature of concrete immediately after placement shall be as specified in Table C.
      - 2) The temperature of concrete as placed shall not exceed the values shown in Table C by more than 20 degrees Fahrenheit.
    - b. Protection temperature:
      - 1) Unless otherwise specified, the minimum temperature of concrete during the protection period shall be as shown Table C.
      - 2) Temperatures specified to be maintained during the protection period shall be those measured at the concrete surface, whether the surface is in contact with formwork, insulation, or air.
      - 3) Measure the temperature with a surface measuring device accurate to 2 degrees Fahrenheit.
      - 4) Measure the temperature of concrete in each placement at regular time intervals as specified in the contract documents.
    - c. Termination of protection:



- 1) The maximum decrease in temperature measured at the surface of the concrete in a 24-hour period shall not exceed the values listed in Table C.
- 2) Do not exceed these limits until the surface temperature of the concrete is within 20 degrees Fahrenheit of the ambient temperature of surrounding temperatures.
- 3) When the surface temperature of the concrete is within 20 degrees Fahrenheit of the ambient temperature, all protection may be removed.

TABLE C CONCRETE TEMPERATURE REQUIREMENTS		
Least dimension of section (inches)	Minimum temperature of concrete as placed and to be maintained during the protection period (degrees Fahrenheit)	Maximum for gradual decrease in surface temperature during any 24 hour period after end of protection period (degrees Fahrenheit)
Less than 12	55	50
12 to less than 36	50	40
36 to 72	45	30
Greater than 72	40	20

3. Curing of concrete:
  - a. Prevent concrete from drying during the required curing period. If water curing is used, terminate use at least 24 hours before any anticipated exposure of the concrete to freezing temperatures.
4. Protection of concrete:
  - a. Combustion heaters: Vent flue gases from combustion heating units to the outside of the enclosures.
  - b. Overheating and drying: Place and direct heaters and ducts to avoid areas of overheating or drying of the concrete surface.
  - c. Maximum air temperature: During the protection period, do not expose the concrete surface to air having a temperature more than 20 degrees Fahrenheit above the values shown in Table C unless higher values are required by an accepted curing method.
  - d. Protection against freezing:
    - 1) Cure and protect concrete against damage from freezing for a minimum of 3 days, unless otherwise specified.
      - a) Maintain the surface temperature of the concrete as specified in Table C.
    - 2) During periods not defined as cold weather, but when freezing temperatures may occur, protect concrete surfaces against freezing for the first 24 hours after placing.

### 3.02 CONCRETE FINISHING

- A. Provide concrete finishes as specified in Section 03366 - Tooled Concrete Finishing as indicated on the Concrete Finish Schedule on the Drawings.



- B. Edges of joints:
1. Provide joints having edges as indicated on the Drawings.
  2. Protect wall and slab surfaces at edges against concrete spatter and thoroughly clean upon completion of each placement.

### 3.03 FIELD QUALITY CONTROL

- A. Testing of concrete:
1. During progress of construction, the Owner will have tests made to determine whether the concrete, as being produced, complies with requirements specified.
  2. Tests will be performed in accordance with ASTM C31, ASTM C39, and ASTM C172.
  3. Contractor shall hire a Certified Independent Laboratory that will make and deliver test cylinders to the laboratory and testing expense will be borne by the Contractor.
  4. Furnish test equipment.
  5. Make provisions for and furnish concrete for test specimens, and provide manual assistance to the Engineer in preparing said specimens.
  6. Assume responsibility for care of and providing of curing conditions for test specimens in accordance with ASTM C31.
  7. Sampling frequency:
    - a. 1 set of test cylinders for each 100 cubic yards of each class of concrete.
    - b. Minimum of 1 set of test cylinders for each class of concrete placed.
    - c. Not less than 1 set of test cylinders for each half-day's placement.
    - d. At least 2 sets of test cylinders for each structure.
- B. Compressive strength tests:
1. Set of 3 cylinder specimens, 6-inch diameter by 12 inch long.
  2. Information: Test 1 cylinder at 7 days.
  3. Acceptance: Test 2 cylinders at 28 days.
- C. Slump tests:
1. Test slump of concrete using slump cone in accordance with ASTM C143.
  2. Do not use concrete that does not meet specification requirements in regards to slump:
    - a. Remove such concrete from project site.
    - b. Test slump at the beginning of each placement, as often as necessary to keep slump within the specified range, and when requested to do so by the Engineer.
- D. Air entrainment tests:
1. Test percent of entrained air in concrete at beginning of each placement, as often as necessary to keep entrained air within specified range, and when requested to do so by the Engineer.
  2. Do not use concrete that does not meet Specification requirements for air entrainment:
    - a. Remove such concrete from project site.
  3. Test air entrainment in concrete in accordance with ASTM C173.
  4. The Engineer may at any time test percent of entrained air in concrete received on project site.



- E. Enforcement of strength requirement:
1. Concrete is expected to reach a compressive strength ( $f'_c$ ) equal to or greater than that the minimum specified in Table A.
  2. Strength level of concrete will be considered acceptable if following conditions are satisfied:
    - a. Averages of all sets of 3 consecutive strength test results is greater or equal to specified compressive strength( $f'_c$ ).
    - b. No individual strength test (average of 2 cylinders) falls below specified compressive strength ( $f'_c$ ) by more than 500 pounds per square inch.
  3. Non-compliant strength tests:
    - a. Mark non-compliant strength test reports to highlight that they contain non-complying results and immediately forward copies of test reports to all parties on the test report distribution list.
    - b. Provide treatment of non-compliant concrete at no additional cost to Owner and with no additional time added to project schedule:
    - c. Initial treatment may consist of additional curing and testing of the affected concrete.
      - 1) Provide additional curing of concrete using means and duration acceptable to the Engineer.
      - 2) Upon completion of the additional curing, provide additional testing designated by the Engineer.
        - a) Obtain and test core samples for compression strength in accordance with ASTM C42, ACI 318, and ACI 350.
        - b) Provide not less than 3 cores for each affected area. Obtain Engineer's acceptance of proposed coring locations before proceeding with that work.
        - c) Submit report of compression strength testing for Engineer's review.
        - d) If required by the Engineer, provide additional cores and obtain petrographic examination in accordance with ASTM C856. Submit report of petrographic analysis for Engineer's review.
      - 3) If additional curing does not bring average of 3 cores taken in affected area to at least the minimum specified compressive strength ( $f'_c$ ), designate such concrete in affected area as defective.

### 3.04 ADJUSTING

- A. Provide repair of defective concrete at no additional cost to Owner and with no additional time added to the project schedule:
- B. Make repairs using approach and means acceptable to the Engineer:
1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
  2. Do not patch, repair, or cover defective work without inspection by the Engineer.
  3. Acceptable means may include, but are not limited to strengthening, repair, or removal and replacement.
- C. Strengthening of defective concrete:
1. By addition of concrete.
  2. By addition of reinforcing.
  3. By addition of both concrete and reinforcing.



D. Repairs:

1. Methods of repair:
  - a. Dry pack method:
    - 1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
    - 2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
  - b. Mortar replacement method:
    - 1) Use for holes too wide to dry pack and too shallow for concrete replacement.
    - 2) Comparatively shallow depressions, large or small, which extend no deeper than nearest surface reinforcement.
  - c. Concrete replacement method:
    - 1) Use when holes extend entirely through concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
2. Preparation of concrete for repair:
  - a. Chip out and key imperfections in the work and make them ready for repair.
  - b. Obtain Engineer's acceptance of surface preparation methods and of prepared surfaces prior to repair.
  - c. Surfaces of set concrete to be repaired: First coat with epoxy bonding agent as specified in Section 03071 - Epoxies.

E. Remove and replace defective concrete.

END OF SECTION



## SECTION 03366

### TOOLED CONCRETE FINISHING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Tooled concrete finishes.

##### 1.02 QUALITY ASSURANCE

- A. Mock-ups:
  - 1. Test panels for concrete finishes:
    - a. Prepare test panels for F4 and F5 finishes and tie-hole repairs for review by Engineer.
    - b. Accepted test panels serve as standard of quality and workmanship for project.
  - 2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
  - 3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
    - a. Accepted test panels serve as standard for repairs during the project.

##### 1.03 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
  - 1. Deliver and store packaged materials in original containers until ready for use.

#### PART 2 PRODUCTS

##### 2.01 MIXES

- A. Mortar mix for F4 finish: Consist of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.
- B. Mortar mix for F5 finish: Consist of 1 part cement to 1-1/2 parts of sand which passes Number 16 screen.

#### PART 3 EXECUTION

##### 3.01 CONCRETE FINISHES

- A. Cement for finishes:
  - 1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.



- B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
1. F1 finish: No special treatment other than repair defective work and fill depressions 1 inch or deeper and tie holes with mortar after removal of curing compound.
  2. F2 finish: No special treatment other than repair defective work, remove fins, fill depressions 1/2 inch or deeper and tie holes with mortar after removal of curing compound.
  3. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
  4. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar.
    - a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
    - b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
    - c. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
    - d. Do not let any material remain on surfaces, except that within pits and depressions.
    - e. Wipe surfaces clean and moist cure.
  5. F5 finish: Receive same finish as specified for F3 finish, and, in addition, receive special stoned finish, in accordance with following requirements:
    - a. Remove forms and perform required repairs, patching, and pointing as specified in this Section.
    - b. Wet surfaces thoroughly with brush and rub with hard wood float dipped in water containing 2 pounds of portland cement per gallon.
    - c. Rub surfaces until form marks and projections have been removed.
    - d. Spread grindings from rubbing operations uniformly over surface with brush in such manner as to fill pits and small voids.
    - e. Moist cure brushed surfaces and allow to harden for 3 days:
      - 1) After curing, obtain final finish by rubbing with carborundum stone of approximately Number 50 grit until entire surfaces have smooth texture and are uniform in color.
      - 2) Continue curing for remainder of specified time.
    - f. If any concrete surface is allowed to become too hard to finish in above specified manner, sandblast and wash related surfaces exposed to view, whether finished or not.
      - 1) While still damp, rub over surface, plastic mortar, as specified for brushed surfaces and handstoned with Number 60 grit carborundum stone, using additional mortar for brushed surfaces until surface is evenly filled without an excess of mortar.
      - 2) Continue stoning until surface is hard.
      - 3) After moist curing for 3 days, make surface smooth in texture and uniform in color by use of Number 50 or Number 60 grit carborundum stone.
      - 4) After stoning, continue curing until 7 day curing period is completed.





- C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:
1. S1 finish: Screeded to grade and leave without special finish.
  2. S2 finish: Smooth steel trowel finish.
  3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.
  4. S4 finish: Steel trowel finish, without local depressions or high points, followed by light hairbroom finish. Do not use stiff bristle brooms or brushes. Perform brooming parallel to slab-drainage. Provide resulting finish that is rough enough to provide nonskid finish. Finish is subject to review and acceptance by the Engineer.
  5. S5 finish: Nonslip abrasive: After concrete has been screeded level and hardened enough to support man standing on a board, sprinkle abrasive from shake screen into surface at uniform rate of 25 pounds for each 100 square feet of surface area, wood float into finish, then trowel abrasive into surface with steel trowel properly exposing abrasive in surface as required to provide nonslip surface.
  6. S6 finish: Roughened finish: After concrete has been screeded to grade, apply a roughened finish by use of a jitterbug roller or similar device.
- D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

### 3.02 CONCRETE FINISH SCHEDULE

- A. Finish concrete surfaces as follows:
1. F4 finish for following vertical surfaces:
    - a. Concrete surfaces specified or indicated to be painted.
    - b. Concrete surfaces, interior or exterior, exposed to view.
  2. Surfaces in open channels, basins, and similar structures:
    - a. F3 finish for vertical surfaces which are normally below water surface.
    - b. F4 finish for vertical surfaces located above normal water surface and exposed to view.
    - c. Remove fins and fill tie holes from concrete surfaces located in closed boxes or channels where there is normally no access or passageway.
  3. S1 finish for following surfaces:
    - a. Projecting footings which are to be covered with dirt.
    - b. Slab surfaces which are to be covered with concrete fill.
  4. S2 finish for following surfaces:
    - a. Tops of corbels.
    - b. Tops of walls and beams not covered above in this Section.
    - c. Tops of slabs not covered above in this Section.
    - d. All other surfaces not specified to be finished otherwise.
  5. S3 finish for following surfaces:
    - a. Building and machine room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.
  6. S4 finish for following surfaces:
    - a. Exterior walkways.
    - b. Tops of exterior walls or beams which are to serve as walkways.
    - c. Tops of exterior walls or beams which are to support gratings.



- d. Top surface of slabs for basins, channels, digesters, and similar structures.
- 7. S6 finish for following surfaces:
  - a. Basin bottoms, or other similar slab surfaces, over which layer of basin bottom grout will be applied.

END OF SECTION



## SECTION 03600

### GROUTING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Cement grout.
  - 2. Cement mortar.
  - 3. Dry-pack mortar.
  - 4. Epoxy grout.
  - 5. Grout.
  - 6. Non-shrink epoxy grout.
  - 7. Non-shrink grout.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
  - 2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
  - 3. C531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
  - 4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes.
  - 5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
  - 6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
  - 7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
  - 8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.
- B. International Concrete Repair Institute (ICRI):
  - 1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

##### 1.03 SUBMITTALS

- A. Cement grout:
  - 1. Mix design.
  - 2. Material submittals.
- B. Cement mortar:
  - 1. Mix design.
  - 2. Material submittals.



- C. Non-shrink epoxy grout:
  - 1. Manufacturer's literature.
- D. Non-shrink grout:
  - 1. Manufacturer's literature.

#### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.
- B. Store materials in cool dry place and in accordance with manufacturer's recommendations.
- C. Handle materials in accordance with the manufacturer's instructions.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURED UNITS**

- A. Non-shrink epoxy grout:
  - 1. Manufacturers: One of the following or equal:
    - a. Five Star Products, Inc., Five Star DP Epoxy Grout.
    - b. BASF Construction Chemicals, Masterflow 648 CP Plus.
    - c. L&M Construction Chemicals, Inc., EPOGROUT.
  - 2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
  - 3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
  - 4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
  - 5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
  - 6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
  - 7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.
- B. Non-shrink grout:
  - 1. Manufacturers: One of the following or equal:
    - a. Five Star Products, Inc., Five Star Grout.
    - b. BASF Construction Chemicals, Masterflow 928.
    - c. L&M Construction Chemicals, Inc., CRYSTEX.
  - 2. In accordance with ASTM C1107.
  - 3. Preportioned and prepackaged cement-based mixture.
  - 4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
  - 5. Require only addition of potable water.
  - 6. Water for pre-soaking, mixing, and curing: Potable water.



7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
  - a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
  - a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
  - b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

## 2.02 MIXES

- A. Cement grout:
  1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
  2. Use same materials for cement grout that are used for concrete.
  3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
  4. For spreading over surfaces of construction or cold joints.
- B. Cement mortar:
  1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
  2. Use same materials for cement mortar that are used for concrete.
  3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
  4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.
- C. Dry-pack mortar:
  1. Proportions by weight: 1 part portland cement to 2 parts concrete sand.
    - a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
    - b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.
- D. Epoxy grout:
  1. Consist of mixture of epoxy or epoxy gel and sand.
    - a. Epoxy: As specified in Section 03071 - Epoxies.
    - b. Epoxy gel: As specified in Section 03071 - Epoxies.
    - c. Sand: Clean, bagged, graded, and kiln-dried silica sand.
  2. Proportioning:
    - a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
    - b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.



- E. Grout:
  - 1. Mix in proportions by weight: 1 part portland cement to 4 parts concrete sand.
    - a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
    - b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.
- F. Non-shrink epoxy grout:
  - 1. Mix in accordance with manufacturer's installation instructions.
- G. Non-shrink grout:
  - 1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

### **3.02 PREPARATION**

- A. Surface preparation for grouting other baseplates:
  - 1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
  - 2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
    - a. Remove loose or broken concrete.
  - 3. Metal surfaces in contact with grout: Grit blast to white metal surface.

### **3.03 INSTALLATION**

- A. Mixing:
  - 1. Cement grout:
    - a. Use mortar mixer with moving paddles.
    - b. Pre-wet mixer and empty out excess water before beginning mixing.
  - 2. Cement mortar:
    - a. Use mortar mixer with moving paddles.
    - b. Pre-wet mixer and empty out excess water before beginning mixing.
  - 3. Dry-patch mortar:
    - a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.
  - 4. Non-shrink epoxy grout:
    - a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
  - 5. Non-shrink grout:
    - a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
    - b. Do not retemper by adding more water after grout stiffens.



B. Placement:

1. Cement grout:
  - a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
  - b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
  - a. Use mortar mixer with moving paddles.
  - b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
  - a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
  - a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
  - b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
  - a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
  - b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:

1. Cement based grouts and mortars:
  - a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
  - b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
  - a. Cure grouts in accordance with manufacturers' recommendations.
    - 1) Do not water cure epoxy grouts.
  - b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:

1. General:
  - a. Use non-shrink grout as specified in this Section.
  - b. Baseplate grouting shall take place from one side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
  - c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
  - d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.





2. Forms and headboxes:
  - a. Build forms using material with adequate strength to withstand placement of grouts.
  - b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
  - c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
  - d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on one side of baseplate.
  - e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

### **3.04 FIELD QUALITY CONTROL**

- A. Non-shrink epoxy grout:
  1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.
- B. Non-shrink grout:
  1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION



## SECTION 03931

### EPOXY INJECTION SYSTEM

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Epoxy injection system.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. C881 - Standard Test Method for Epoxy-Resin-Base Bonding Systems for Concrete.
  - 2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
  - 3. D638 - Standard Test Method for Tensile Properties of Plastics.
  - 4. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
  - 5. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
  - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
- B. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.

##### 1.03 SUBMITTALS

- A. General: Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. Manufacturer's data completely describing epoxy injection system materials, and including test methods and results for strength in tension, flexure, compression and bond; flexural modulus of elasticity; coefficient of thermal expansion; and elongation.
  - 2. Data demonstrating that products are listed under NSF-61 for use in direct contact with potable water.
- C. Quality control submittals:
  - 1. Certificates of Compliance.
  - 2. Manufacturer's Instructions.
- D. Special procedure submittals:
  - 1. Protection plan for surrounding areas and non-cementitious surfaces.

##### 1.04 QUALITY ASSURANCE

- A. Products:
  - 1. Provide materials that are new and use them within shelf life limitations set forth by manufacturer.



- B. Qualifications:
  - 1. Installer:
    - a. Minimum 5 years' experience in concrete repair, with focus on application of similar systems and products to projects of similar size and scope.
- C. Pre-installation meeting:
  - 1. At least 1 week prior to commencing work of this Section, convene a meeting at the project site to review and discuss the following:
    - a. Surface preparation.
    - b. Substrate conditioning and pre-treatment.
    - c. Installation procedures.
    - d. Environmental conditions (including weather forecast) and curing requirements.
    - e. Testing and inspection procedures.
    - f. Protection of surrounding surfaces and equipment.

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Labels shall include product identification, batch numbers, and shelf life information.
- B. Store materials off the ground and away from moisture and direct sunlight, and at temperatures within manufacturer's recommended range.
- C. Pre-condition materials to manufacturer's recommended temperatures before mixing and using.

#### **1.06 PROJECT CONDITIONS**

- A. Take precautions to protect surfaces and equipment in the work area from damage and staining.

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**

- A. General:
  - 1. Repair materials shall be free of chlorides or alkalis (except for those attributed to water).
  - 2. To ensure compatibility of materials and methods, a single manufacturer shall produce and provide all products used together in a single area of concrete repair.
  - 3. Listed under NSF-61 for use in direct contact with potable water.
- B. Manufacturers: One of the following or equal:
  - 1. BASF Building Systems, MasterInject 1500 (formerly Concrecive Standard LVI).
  - 2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.



- C. Epoxy:
1. In accordance with ASTM C881, Types I, II and IV, Grade 1, Class C.
  2. Water-insensitive 2-component low viscosity, epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

Table 1 - Epoxy, Physical Properties		
Characteristic	Test Method	Required Results, minimum <sup>(1,2)</sup>
Viscosity (mixed)	--	250 - 375 centipoise
Tensile Strength	ASTM D638	7,500 pounds per square inch
Tensile Elongation at Break	ASTM D638	1 percent
Compressive Strength	ASTM D695	11,000 pounds per square inch
Compressive Modulus	ASTM D695	2.5 x 10 <sup>5</sup> pounds per square inch.
Bond Strength, slant shear, hardened concrete to hardened concrete	ASTM C882	1500 pounds per square inch at 2 days at minimum 73 degrees Fahrenheit. Concrete shall fail before failure of epoxy.
Heat Deflection Temperature	ASTM D648	124 degrees Fahrenheit
Notes:		
1)	Properties for mixes with neat epoxy.	
2)	Results after 7-day cure at temperature between 72 and 78 degrees Fahrenheit, unless otherwise noted.	

## 2.02 EQUIPMENT

- A. Injection pump:
1. Use positive displacement injection pump with interlock to provide in-line mixing and metering system for 2 component epoxy.
  2. Use pressure hoses and injection nozzle designed to properly mix of 2 components of epoxy.
  3. Standby injection unit may be required.

## PART 3 EXECUTION

### 3.01 PREPARATION

- A. Surface preparation:
1. Confirm that surface temperature and moisture conditions are within manufacturer's recommended limits. Condition surfaces to within those limits before commencing epoxy injection.
  2. Sweep or clean area in vicinity of cracks that will be injected with epoxy. Leave area in generally clean condition after epoxy injection is complete.
  3. Clean cracks so they are free from dirt, laitance, and other loose matter.



## 3.02 INSTALLATION

- A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.
- B. Mixing:
  - 1. Mix epoxy in accordance with manufacturer's installation instructions.
  - 2. Do not use solvents to thin epoxy system materials introduced into cracks or joints.
- C. Injection:
  - 1. Apply adequate surface seal to crack to prevent leakage of epoxy.
  - 2. Establish injection points at distance along crack not less than thickness of cracked member.
  - 3. Crack injection sequence:
    - a. Inject epoxy into crack or joint at first port with sufficient pressure to advance epoxy to adjacent port. Start at lowest port along the injection line and work upwards.
    - b. Seal original port and shift injection to next adjacent port where epoxy appears.
    - c. Continue port-to-port injection until crack has been injected for its entire length.
    - d. For small amounts of epoxy, or where excessive pressure developed by injection pump might further damage structure, premixed epoxy and use hand caulking gun to inject epoxy if acceptable to the Engineer.
    - e. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
    - f. After epoxy injection is complete, remove surface seal material, and refinish concrete in area where epoxy was injected to match existing concrete. Leave finished work and work area in a neat, clean condition.

## 3.03 FIELD QUALITY ASSURANCE

- A. Provide Contractor quality control as specified in Section 01450 - Quality Control.
- B. Field inspections and testing:
  - 1. Submit records of inspections and tests to Engineer within 24 hours after completion.
- C. Manufacturer's services.
  - 1. Pre-installation meeting: Provide manufacturer's technical representative to attend pre-installation meeting specified in this Section.

## 3.04 FIELD QUALITY CONTROL

- A. Provide Owner's quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.
- B. Special inspections special tests, and structural observation:
  - 1. Not required.



- C. Field inspections:
  - 1. Preparation.
    - a. Review manufacturer's product data and installation instructions.
  - 2. Required inspections.
    - a. Observe surfaces to be injected for temperature and moisture conditions and for surface preparation.
    - b. Observe conditioning and mixing of epoxy resin components.
    - c. Observe injection procedures for filling cracks.
  - 3. Records of inspections:
    - a. Provide record of each inspection.
    - b. Submit to Engineer upon request.

### **3.05 NON-CONFORMING WORK**

- A. Rework surface finishes that do not match surrounding concrete to the satisfaction of Engineer at no additional cost to Owner.

END OF SECTION







## SECTION 05120

### STRUCTURAL STEEL

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Structural steel shapes and plate.
  - 2. Fasteners and structural hardware:
    - a. All thread rods.
    - b. All thread rods, high-strength.
    - c. Forged steel structural hardware.
    - d. High-strength bolts.
  - 3. Welding.
  - 4. Bolting.

##### 1.02 REFERENCES

- A. American Institute of Steel Construction (AISC):
  - 1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
  - 2. 360 - Specification for Structural Steel Buildings.
- B. American Iron and Steel Institute (AISI):
  - 1. Steel and stainless steel alloys ("types") as indicated.
- C. American Welding Society (AWS):
  - 1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
  - 2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
  - 3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
  - 4. D1.1 - Structural Welding Code - Steel.
  - 5. D1.6 - Structural Welding Code - Stainless Steel.
- D. ASTM International (ASTM):
  - 1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
  - 2. A36 - Standard Specification for Carbon Structural Steel.
  - 3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 6. A489 - Standard Specification for Carbon Steel Lifting Eyes.
  - 7. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
  - 8. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.



9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  10. A992 - Standard Specification for Structural Steel Shapes.
  11. F436 - Standard Specification for Hardened Steel Washers.
  12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
  13. F594 - Standard Specification for Stainless Steel Nuts.
  14. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
  15. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi Yield Strength.
  16. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
  17. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

### **1.03 DEFINITIONS**

- A. Snug-tight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

### **1.04 SUBMITTALS**

- A. Product data:
1. Welding electrodes for field welds: Electrode manufacturer's data.
- B. Shop drawings:
1. Fabrication and erection drawings.
- C. Quality control submittals:
1. Welding procedure specifications (WPS) in accordance with AWS D1.1 and D1.6.
    - a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
      - 1) State electrode manufacturer and specific electrodes used.
      - 2) Indicate required AWS qualification for joint.
    - b. Submit WPS with shop drawings that indicate those welds.
    - c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1 and D1.6 for welding procedures qualified by testing.
  2. Welder qualifications: For each welding process and position:
    - a. Welder's qualification certificates.
    - b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1 and D1.6.
  3. Steel fabricator's AISC certification.



- D. Test reports:
  - 1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

## **1.05 QUALITY ASSURANCE**

- A. Certification:
  - 1. Steel fabricators shall be certified by the AISC or other certification acceptable to the Engineer and the building official having jurisdiction.
- B. Welding:
  - 1. Perform welding of structural metals in accordance with AWS D1.1 and D1.6 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
  - 2. Make Welding Procedure Specifications available at the locations where welding is performed.
  - 3. Notify Engineer at least 24 hours before starting shop or field welding.
  - 4. Engineer may check materials, equipment, and qualifications of welders.
  - 5. Remove welders performing unsatisfactory Work, or require requalification.
  - 6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
  - 7. Contractor shall bear costs of retests on defective welds.
  - 8. Contractor shall also bear costs in connection with qualifying welders.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.
- B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

### **2.02 FASTENERS AND STRUCTURAL HARDWARE**

- A. General:
  - 1. Materials: Of domestic manufacture.
  - 2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.
- B. All thread rods:
  - 1. Carbon steel:
    - a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.



- b. High strength all thread rods: In accordance with ASTM F1554, Grade 55.
    - c. Nuts: ASTM A194.
    - d. Washers: ASTM F436.
  - 2. Galvanized carbon steel:
    - a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
    - b. High strength galvanized all thread rods: In accordance with ASTM F1554, Grade 55, and galvanized in accordance with ASTM F2329.
    - c. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
    - d. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.
  - 3. Stainless steel:
    - a. Units descaled, pickled, and passivated as specified in "Fabrication" in this Section.
    - b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
    - c. Type 316:
      - 1) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
      - 2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
      - 3) Washers: Type 316 stainless steel.
- C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- D. Forged steel structural hardware - carbon steel:
  - 1. Clevises and turnbuckles: Forged steel in accordance with AISI C-1035. .
  - 2. Eye nuts / Eye bolts: Forged steel in accordance with AISI C-1030.
    - a. Having geometric and strength characteristics (including proof load, breaking strength, tensile strength, bend test, and impact strength) of eyebolts in accordance with ASTM A489, Type 1.
  - 3. Sleeve nuts: Forged steel in accordance with AISI C-1018 Grade 2.
- E. High-strength bolts:
  - 1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Provide uncoated components unless galvanized coating is indicated on the Drawings.
  - 2. Carbon steel - Uncoated:
    - a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1, or ASTM F3125, Grade A490, Type 1 where Grade A490 bolts are indicated on the Drawings.
    - b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
    - c. Washers:
      - 1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
      - 2) Adjacent to long slotted holes: Fabricated from 5/16-inch thick plate conforming to ASTM A36.
    - d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:



- 1) Compressible washer type direct tension indicators ("DTI"): In accordance with ASTM F959, Type 325-1, or ASTM F959, Type 490-1 where Grade A490 bolts are indicated on the Drawings.
  - 2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 or ASTM F3125, Grade F2280 where Grade A490 bolts are indicated on the Drawings.
3. Carbon steel - Galvanized:
- a. Bolt and nut assemblies fabricated, galvanized, tested for rotational capacity, and shipped accordance with the provisions ASTM F3125, Grade A325 and the RCSC Specification.
  - b. Bolts, nuts, and washers: Hot-dip galvanized in accordance with ASTM F2329.
  - c. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1 and galvanized as specified.
  - d. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade DH, galvanized as specified, and lubricated in accordance with ASTM A563, Supplementary Requirement S1 to minimize galling.
  - e. Washers:
    - 1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1 and galvanized as specified. Flat circular washers unless otherwise indicated on the Drawings.
    - 2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel conforming to ASTM A36, and galvanized in accordance with ASTM A123.
  - f. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
    - 1) Compressible washer type direct tension indicators ("DTI"): In accordance with ASTM F959, Type 325-1, with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
    - 2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
- F. Stainless steel bolts (for use in stainless steel structures):
1. General:
    - a. Bolts and nuts shall be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship bolts with properly fitting nuts attached.
    - b. Units descaled, pickled and passivated as specified in "Fabrication."
  2. Type 316:
    - a. Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
    - b. Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
    - c. Washers: Type 316 stainless steel.
  3. Welded studs: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## **2.03 ISOLATING SLEEVES AND WASHERS**

- A. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete.



04

## **GALVANIZED SURFACE REPAIR**

- A. Manufacturers: The following or equal:
1. Jelt, Galvinox.

## **2.05 THREAD COATING**

- A. Manufacturers: One of the following or equal:
1. Bostik, Never-Seez.
  2. Oil Research, Inc., WLR No. 111.

## **2.06 SUPPLEMENTARY PARTS**

- A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

## **2.07 FABRICATION**

- A. Shop assembly:
1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
  2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
  3. Round off sharp and hazardous projections and grind smooth.
  4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
  5. Take responsibility for correct fitting of metalwork.
  6. Welded connections:
    - a. Comply with AWS requirements for the metals to be welded.
    - b. Weld only in accordance with approved Welding Procedure Specifications.
    - c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.
- B. Stainless steel shapes and assemblies:
1. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
    - a. Fabricate shapes using laser-fused, full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as that of members indicated on the Drawings.
    - b. Fabricate shapes from dual grade stainless steel.
    - c. Fabricate beams and channels to ASTM A6 tolerances.
    - d. Manufacturers: The following or equal:
      - 1) Stainless Structural, LLC.
  2. Cleaning and passivation:
    - a. Following shop fabrication of stainless steel members and bolts, clean and passivate fabrications at point of manufacture.
    - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a bright passive finished surface with no etching, pitting, frosting, or discoloration.





- c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
  - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
- d. Pre-clean, chemically de-scale ("pickle"), passivate, and final-clean fabrications in accordance with the requirements of ASTM A380.
  - 1) If degreasing is required before cleaning (pickling) to remove scale or iron oxide, cleaning with citric acid treatments is permissible; however, such treatments shall be followed inorganic cleaners.
  - 2) Pickle and passivate stainless steel using a nitric acid solution in accordance with ASTM A380, Annex A2, Table A2.1, Part II.
  - 3) Pickling by citric acid treatment or sulfuric acid treatment is not considered to satisfy the requirements of this Section.
- e. Inspect after cleaning using methods specified for "gross inspection" in ASTM A380.
- f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the site.

C. Galvanized carbon steel:

- 1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123:
- 2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
- 3. Re-straighten galvanized items that bend or twist during galvanizing.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.02 ERECTION**

- A. General:
  - 1. Fabricate structural and foundry items to true dimensions without warp or twist.
  - 2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
  - 3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
  - 4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
  - 5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
  - 6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
  - 7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.





8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
  9. Round off sharp or hazardous projections and grind smooth.
  10. Paint or coat steel items as specified in Sections 09910 - Painting and 09960 - High-Performance Coatings.
- B. Stainless steel. Take all necessary precautions to avoid iron contamination of stainless steel during delivery, storage, and handling.
1. Segregate stainless steel from iron.
  2. Tools and handling devices.
    - a. Do not use iron tools clamps, chokes, working surfaces, or brushes when fabricating, handling, and erecting stainless steel.
    - b. Do not use tools that have been contaminated by contact with iron.
    - c. Use stainless steel, polymer coated, or wood tools and handling equipment. Do not use tools that have been contaminated by contact with iron or steel.
- C. Welding: General:
1. Make welds full penetration type, unless otherwise indicated on the Drawings.
  2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.
- D. Welding: Carbon steel:
1. General: In accordance with AWS D1.1:
    - a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
    - b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.
- E. Welding - stainless steel:
1. General: In accordance with AWS D1.6.
  2. Field welding of stainless steel will not be permitted.
  3. Passivation of field-welded surfaces:
    - a. Provide cleaning, pickling and passivating as specified under "Fabrications" of this Section. Clean using Derustit Stainless Steel Cleaner, or equal.
- F. Interface with other products:
1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.



- G. Fasteners: General:
1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
  2. Anchor bolts and anchor rods: Install as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    - a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snug-tight" condition.
  3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
  4. All thread rods in drilled holes bonded to masonry with adhesive: Install as specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.
- H. Fasteners: High-strength carbon steel bolts:
1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
  2. Provide slip-critical joints at bolted connections.
  3. Joints: Slip-critical.
    - a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
    - b. Furnish hardened flat washers in accordance with ASTM F436:
      - 1) On outer plies with slotted holes.
      - 2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
      - 3) Under element, nut, or bolt head, turned in tightening.
    - c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
    - d. Tighten bolts to full pretension.
- I. Fasteners: Stainless steel bolts:
1. Connections shall be snug-tight joints unless otherwise indicated on the Drawings.
  2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
  3. Rotate nuts using a slow, smooth action without interruptions. Avoid over-tightening.

### **3.03 FIELD QUALITY CONTROL**

- A. Provide quality control as specified in Section 01450 - Quality Control.

### **3.04 FIELD QUALITY ASSURANCE**

- A. Provide quality assurance as specified in Section 01450 - Quality Control.
- B. Special inspections, special tests, and structural observation:
1. Provide as specified in Section 01455 - Special Tests and Inspections.

END OF SECTION





## SECTION 05140

### STRUCTURAL ALUMINUM

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
  - 2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
  - 3. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
- B. American Welding Society (AWS):
  - 1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
  - 2. D1.2 - Structural Welding Code - Aluminum.

##### 1.03 SUBMITTALS

- A. Quality control submittals:
  - 1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
  - 2. Welder's certificates.

##### 1.04 QUALITY ASSURANCE

- A. Qualifications:
  - 1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
  - 2. Notify Engineer 24 hours minimum before starting shop or field welding.
  - 3. Engineer may check materials, equipment, and qualifications of welders.
  - 4. Remove welders performing unsatisfactory work, or require to requalify.
  - 5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
  - 6. Contractor shall bear costs of retests on defective welds.
  - 7. Contractor shall bear costs in connection with qualifying welders.



## ART 2 PRODUCTS

### 2.01 MATERIALS

- A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.
- B. Structural aluminum: ASTM B308, Alloy 6061-T6.
- C. Extruded aluminum: ASTM B221, Alloy 6063-T42.
- D. Isolating sleeves and washers:
  - 1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- E. Miscellaneous materials:
  - 1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
  - 2. Size, form, attachment, and location shall conform to the best of current practice.
  - 3. Conform to applicable ASTM Standards for materials not otherwise specified.

### 2.02 FABRICATION

- A. Aluminum layout:
  - 1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
  - 2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.
- B. Cutting aluminum:
  - 1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
  - 2. Material more than 1/2-inch thick: Saw or rout.
  - 3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
  - 4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
  - 5. Do not flame cut aluminum alloys.
  - 6. Punch or drill rivet or bolt holes to finished size before assembly:
    - a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
    - b. Make holes cylindrical and perpendicular to principal surface.
    - c. Do not permit holes to drift in a manner to distort metal.
- C. Aluminum forming and assembly:
  - 1. Do not heat structural aluminum, except as follows:
    - a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
    - b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.
- D. Before assembly, remove chips lodged between contacting surfaces.
- E. Welding aluminum:
  - 1. Perform welding of aluminum in accordance with AWS D1.2.



2. Weld aluminum in accordance with the following:
  - a. Preparation:
    - 1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
    - 2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
    - 3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
    - 4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
  - b. Filler metal: Aluminum alloys conforming to the requirements of AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
  - c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
  - d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
  - e. Do not use welding process that requires use of a welding flux.
  - f. Neatly make welded closures.
  - g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
  - h. Make welds full penetration welds unless otherwise indicated on the Drawings.

## **2.03 FINISHES**

- A. Coating for dissimilar metals:
  1. Alkali resistant bitumastic:
    - a. Manufacturers: One of the following or equal:
      - 1) Carboline, Bitumastic 50.
      - 2) Tnemec, 46-465.
      - 3) Wasser, MC-Tar 100.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.02 INSTALLATION**

- A. Install structural aluminum products as indicated on the Drawings and specified.
- B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.



- C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
- D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.
- E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.
- F. Interface with other products:
  - 1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
  - 2. Do not paint exposed aluminum surfaces. Remove markings and leave surfaces clean. Coat those parts of aluminum which will be cast into concrete, and those parts of aluminum which will come in contact with masonry, concrete, or wood, with a minimum of 2 coats of specified coating for protection of similar metals.
  - 3. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09960 - High-Performance Coatings.

END OF SECTION





## SECTION 05190

### MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Cast-in anchors and fasteners:
    - a. Anchor bolts.
    - b. Anchor rods.
    - c. Concrete inserts.
    - d. Deformed bar anchors.
    - e. Welded studs.
  - 2. Post-installed steel anchors and fasteners:
    - a. Concrete anchors.
    - b. Sleeve anchors.
    - c. Screw anchors.
    - d. Undercut concrete anchors.
  - 3. Appurtenances for anchoring and fastening:
    - a. Anchor bolt sleeves.
    - b. Isolating sleeves and washers.
    - c. Thread coating for threaded stainless steel fasteners.

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
  - 1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.
- B. American National Standards Institute (ANSI):
  - 1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.
- C. American Welding Society (AWS):
  - 1. D1.1 - Structural Welding Code - Steel.
  - 2. D1.6 - Structural Welding Code - Stainless Steel.
- D. ASTM International (ASTM):
  - 1. A29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for.
  - 2. A36 - Standard Specification for Carbon Structural Steel.
  - 3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
  - 4. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
  - 5. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 6. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.



7. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
  8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  10. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
  11. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
  12. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
  13. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
  14. F436 - Standard Specification for Hardened Steel Washers.
  15. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
  16. F594 - Standard Specification for Stainless Steel Nuts.
  17. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
  18. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
- E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

### 1.03 DEFINITIONS

- A. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.
- B. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.
- C. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.
- D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.
- E. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.
- F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
1. Corrosive locations: Describes interior and exterior locations as follows:
    - a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.



- b. Exterior and interior locations at the following treatment structures:
  - 1) Water treatment facilities: All Liquids stream.
  - 2) Water treatment facilities: All Solids stream.
- 2. Wet and moist locations: Describes locations, other than “corrosive locations,” that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
  - a. Exterior portions of buildings and structures.
  - b. Liquid-containing structures:
    - 1) Locations at and below the maximum operating liquid surface elevation.
    - 2) Locations above the maximum operating liquid surface elevation and:
      - a) Below the top of the walls containing the liquid.
      - b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
  - c. Liquid handling equipment:
    - 1) Bases of pumps and other equipment that handles liquids.
  - d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
  - e. Other locations indicated on the Drawings.
- 3. Other locations:
  - a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

#### **1.04 SUBMITTALS**

- A. General:
  - 1. Submit as specified in Section 01330 - Submittal Procedures.
  - 2. Submit information listed for each type of anchor or fastener to be used.
- B. Action submittals:
  - 1. Product data:
    - a. Cast-in anchors:
      - 1) Manufacturer's data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
    - b. Post-installed anchors:
      - 1) For each anchor type, manufacturer's data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
  - 2. Samples:
    - a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
  - 3. Certificates:
    - a. Cast-in anchors:
      - 1) Mill certificates for steel anchors that will be supplied to the site.
    - b. Post-installed anchors:
      - 1) Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.



4. Test reports:
  - a. Post-installed anchors: For each anchor type used for the Work:
    - 1) Current ICC-ES Report (ESR) demonstrating:
      - a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.
5. Manufacturer's instructions:
  - a. Requirements for storage and handling.
  - b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
  - c. Requirements for inspection or observation during installation.
6. Qualification statements:
  - a. Post-installed anchors: Installer qualifications:
    - 1) Submit list of personnel performing installations and include date of manufacturer's training for each.

## **1.05 QUALITY ASSURANCE**

- A. Qualifications:
  1. Post installed anchors shall be in accordance with building code specified in Section 01410 - Regulatory Requirements.
  2. Installers: Post-installed mechanical anchors:
    - a. Conduct a training session with the manufacturer's authorized technical representative for the project on-site:
      - 1) Training shall cover the complete installation process for each type of anchor to be used and shall include, but not be limited to, hole drilling procedures and techniques, hole preparation and cleaning, bolt installation, and bolt proof loading and torquing.
      - 2) Use only trained and qualified personnel for anchor installation.
    - b. Installations shall be performed by trained installers having at least 3 years of experience performing similar installations with similar types of anchors.
- B. Special inspection:
  1. Provide special inspection of post-installed anchors as specified in Section 01455 - Special Tests and Inspections and this Section.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.
- B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.
- C. Protect anchors from weather and moisture until installation.

## **1.07 PROJECT CONDITIONS**

- A. As specified in Section 01610 - Project Design Criteria.
- B. Seismic Design Category (SDC) for structures is indicated on the Drawings.



## **PART 2 PRODUCTS**

### **2.01 MANUFACTURED UNITS**

#### **A. General:**

1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
  - a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
  - b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

#### **B. Materials:**

1. Provide and install anchors of materials as in this Section.

### **2.02 CAST-IN ANCHORS AND FASTENERS**

#### **A. Anchor bolts:**

1. Description:
  - a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
  - b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
    - 1) Rods or bars with angle bend for embedment in concrete (i.e., "L" or "J" shaped anchor bolts) are not permitted in the Work.
2. Materials:
  - a. Ship anchor bolts with properly fitting nuts attached.
  - b. Type 316 stainless steel:
    - 1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
    - 2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
    - 3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
    - 4) Washers: Type 316 stainless steel.
  - c. Galvanized steel:
    - 1) Hot-dip galvanized coating in accordance with ASTM F2329.
    - 2) Bolt: ASTM F1554, Grade 55, heavy hex, coarse thread.
    - 3) Nuts: ASTM A563, Grade A heavy hex, threads to match bolt.
    - 4) Washers: ASTM F436, Type 1.



- B. Anchor rods:
1. Description: Straight steel rod having threads on each end or continuously threaded from end to end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
  2. Materials:
    - a. Stainless steel: Type 316:
      - 1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
      - 2) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
      - 3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of rods.
      - 4) Washers: Type 316 stainless steel.
      - 5) Plates (embedded): ASTM A240.
    - b. Galvanized: steel:
      - 1) Hot-dip galvanized with coating in accordance with ASTM F2329.
      - 2) Rod: ASTM F1554, Grade 55, coarse thread.
      - 3) Nuts: ASTM A563, Grade A, threads to match rod.
      - 4) Washers: ASTM F436, Type 1.
      - 5) Plates (embedded): ASTM A572 Grade 50.
- C. Concrete insert: Ductile embed:
1. Description: 1-piece, integrally hot forged sleeve for embedment in concrete. Provided with flange for nailing to forms and female threaded coupler at the exposed concrete face, and washer-faced hex headed foot to resist pullout from concrete at the embedded end.
  2. Manufacturers: The following or equal:
    - a. Dayton Superior, F-54 Ductile Embed Insert.
  3. Materials:
    - a. Stainless steel: Not available.
    - b. Galvanized steel:
      - 1) Hot-dip galvanized coating in accordance with ASTM A123 or A153 where indicated on the Drawings.
      - 2) Steel: ASTM A29 hot rolled, Grade 1045.
- D. Deformed bar anchors:
1. Description: Steel rod with rebar-like deformations along its length and welding ferrule at one end for attachment to structural steel members (plates or shapes).
  2. Manufacturers: One of the following or equal:
    - a. Nelson Stud Welding Co., D2L Deformed Bar Anchors (D2L-DBA).
    - b. Stud Welding Products, Inc., Deformed Anchor Studs.
  3. Materials:
    - a. Galvanized steel:
      - 1) Hot-dip galvanized coating in accordance with ASTM A153 where indicated on the Drawings.
      - 2) Steel: ASTM A1064 wire deformed for concrete reinforcement.



- E. Welded studs:
1. Description: Anchor with forged head for embedment into concrete on one end, and welding ferrule for attachment to steel on the other. Welded to steel members or plates to provide anchorage for steel connections to concrete.
  2. Acceptance criteria:
    - a. Welded studs in accordance with AWS D1.1, Type B.
  3. Manufacturers: One of the following or equal:
    - a. Nelson Stud Welding Co., H4L Concrete Anchors or S3L Shear Connectors as indicated on the Drawings.
    - b. Stud Welding Products, Headed Concrete Anchors (HCA) or Headed Shear Connectors (HSC) as indicated on the Drawings.
  4. Materials:
    - a. Stainless steel: Type 316L:
    - b. Galvanized steel:
      - 1) Hot-dip galvanized after fabrication with coating in accordance with ASTM A123.
      - 2) Steel: Carbon steel in accordance with ASTM A108 with 50,000 pounds per square inch minimum yield strength, and 60,000 pounds per square inch minimum tensile strength.
- F. Steel plates or shapes for fabrications including assemblies with welded studs or deformed bar anchors:
1. Stainless steel: Type 316L:
    - a. Plates (embedded): ASTM A240.
  2. Galvanized steel:
    - a. Hot dip galvanized in accordance with ASTM A123.
    - b. Steel: ASTM A572 Grade 50.

### **2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE**

- A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete:  
As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
- B. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in masonry:  
As specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

### **2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL**

- A. General:
1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01410 - Regulatory Requirements. Reports prepared by other recognized evaluation agencies may be submitted for consideration if acceptable to the Engineer and to the authority having jurisdiction.
    - a. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
      - 1) In regions of concrete where cracking has occurred or may occur.
      - 2) To resist short-term loads due to wind forces.
      - 3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.





2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
    - a. Calculations shall be prepared by and shall bear the signature and seal of a Professional Engineer licensed in the State of Texas .
    - b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.
- B. Concrete anchors:
1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
    - a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
  2. Concrete anchors for anchorage to concrete:
    - a. Acceptance criteria:
      - 1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
      - 2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
    - b. Manufacturers: One of the following or equal:
      - 1) Hilti, Kwik Bolt TZ Expansion Anchor.
      - 2) DEWALT/Powers, PowerStud.
      - 3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
    - c. Materials. Integrally threaded stud, wedge, washer, and nut:
      - 1) Stainless steel: Type 316.
      - 2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).
- C. Sleeve anchors:
1. Description: Post-installed, torque-controlled anchor assembly consisting of an externally threaded stud with a spacer sleeve near the surface of the base material, and an expansion sleeve on the lower part of the stud. The expansion sleeve is forced outward by torquing of the center stud to transfer load.
    - a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.



2. Sleeve anchors for anchorage to concrete:
  - a. Acceptance criteria:
    - 1) Sleeve anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    - 2) Sleeve anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
  - b. Manufacturers: One of the following or equal:
    - 1) Hilti, HSL-3 Heavy Duty Expansion (sleeve) Anchor.
    - 2) DEWALT/Powers, Power Bolt+ Heavy Duty Sleeve Anchor.
  - c. Materials:
    - 1) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

D. Screw anchors:

1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creating a helical "key" that is larger than the diameter of the bolt itself along the length of the anchor shaft.
2. Screw anchors for anchorage to concrete:
  - a. Acceptance criteria:
    - 1) Screw anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    - 2) Screw anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
  - b. Manufacturers: Screw anchor: One of the following or equal:
    - 1) Hilti, Hex head, HUS-EZ Screw Anchor:
      - a) With internally threaded head: HUS-EZ I Hanger Anchor.
    - 2) DEWALT/Powers, Screwbolt+ Screw Anchor:
      - a) With internally threaded head: Vertigo+ Rod Hanging System.
    - 3) Simpson Strong-Tie, Titen® HD Screw Anchor:
      - a) With internally threaded head: Titen® HD Rod Hanger.
  - c. Materials:
    - 1) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or equal.

E. Undercut concrete anchors:

1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creation of an undercut "key" at the embedded end of the anchor. The undercut may be achieved with a special drill before anchor installation, or by the anchor itself during installation.



2. Acceptance criteria:
  - a. Acceptance criteria:
    - 1) Undercut concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    - 2) Undercut anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
  - b. Use pre-setting units. Through-setting units are not allowed unless prior written acceptance for specific locations is obtained from the Engineer.
3. Manufacturers: One of the following or equal:
  - a. Hilti, HDA (carbon steel) or HDA-R (stainless steel) Undercut Anchor.
  - b. Powers Fasteners, Atomic+ Undercut Anchor.
  - c. Simpson Strong-Tie, Torq-Cut Anchor.
  - d. USP Structural Connectors, DUC-L Undercut Anchors.
4. Materials:
  - a. Stainless steel: Corrosive, wet, and moist and locations: Type 316.
  - b. Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

## **2.05 APPURTENANCES FOR ANCHORING AND FASTENING**

- A. Anchor bolt sleeves:
  1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
  2. Plastic sleeves:
    - a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
    - b. Manufacturers: The following or equal:
      - 1) Portland Bolt & Manufacturing Co.
  3. Fabricated steel sleeves: Construct as specified in Section 05500 - Metal Fabrications:
    - a. At galvanized carbon steel anchor bolts, provide galvanized carbon steel sleeves.
    - b. At stainless steel anchor bolts, provide stainless steel sleeves of same Type 316 as bolt, except that sleeves shall be constructed from low carbon stainless steel for welding 316L.
- B. Isolating sleeves and washers:
  1. Manufacturers: One of the following or equal:
    - a. Central Plastics Co.
    - b. Allied Corrosion Industries.
  2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
  3. One sleeve required for each bolt.
  4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
    - a. Proper size to fit bolts.



- b. Two 1/8-inch thick steel washers for each bolt.
- c. G3 Phenolic: 2 insulating washers are required for each bolt:
  - 1) Thickness: 1/8 inch.
  - 2) Base material: Glass.
  - 3) Resin: Phenolic.
  - 4) Water absorption: 2 percent.
  - 5) Hardness (Rockwell): 100.
  - 6) Dielectric strength: 450 volts per mil.
  - 7) Compression strength: 50,000 pounds per square inch.
  - 8) Tensile strength: 20,000 pounds per square inch.
  - 9) Maximum operating temperature: 350 degrees Fahrenheit.
- C. Coating for repair of galvanized surfaces:
  - 1. Manufacturers: The following or equal:
    - a. Jelt, Galvinox.
- D. Thread coating: For use with threaded stainless steel fasteners:
  - 1. Manufacturers: One of the following or equal:
    - a. Bostik, Never-Seez.
    - b. Oil Research, Inc., WLR No. 111.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.02 INSTALLATION: GENERAL**

- A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.
- B. Substitution of anchor types:
  - 1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
  - 2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.
- C. Protect products from damage during installation. Take special care to protect threads and threaded ends.
- D. Accurately locate and position anchors and fasteners:
  - 1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
  - 2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.



- E. Interface with other products:
1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
  2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

### 3.03 INSTALLATION: CAST-IN ANCHORS

- A. General:
1. Accurately locate cast-in and built-in anchors.
    - a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
    - b. Brace or tie off embeddings as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
    - c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
    - d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
  2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
  3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.
- B. Anchor bolts:
1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
  2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Seal top of sleeve to prevent grout from filling sleeve.
- C. Anchor rods:
1. Install as specified for anchor bolts.
- D. Concrete inserts:
1. Provide inserts with minimum clear concrete cover not less than that specified for reinforcing bars.
- E. Deformed bar anchors:
1. Butt weld to steel fabrications with automatic stud welding gun as recommended by manufacturer.
  2. Ensure that butt weld develops the full strength of the anchor.
- F. Welded studs:
1. Butt weld to steel fabrications with automatic stud welding gun as recommended by the manufacturer.
  2. Ensure that butt weld develops full strength of the stud.



### **3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS**

- A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
- B. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in masonry: As specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

### **3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS**

- A. General:
  - 1. Install anchors in accordance with the manufacturer's instructions, ACI 355.2, the anchor's ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.
  - 2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
  - 3. After anchors have been positioned and inserted into concrete or masonry, do not:
    - a. Remove and reuse/reinstall anchors.
    - b. Loosen or remove bolts or studs.
- B. Holes drilled into concrete and masonry:
  - 1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength ( $f'_c$  or  $f'_m$ ).
  - 2. Accurately locate holes:
    - a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
    - b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
  - 3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
    - a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
  - 4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
  - 5. Drill using anchor manufacturer's recommended equipment and procedures:
    - a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
      - 1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
      - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
  - 6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.



7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
  - a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
  - b. Repeat cleaning process as required by the manufacturer's installation instructions.
  - c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.
- C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions.
  1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.
- D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2 1/2 inch	2 5/8 inch	8 inch
1/2 inch	3 1/2 inch	3 1/2 inch	8 inch
5/8 inch	4 1/2 inch	4 1/2 inch	10 inch
3/4 inch	5 inch	5 1/4 inch	12 inch

- E. Flush shell anchors:
  1. Flush shell anchors are not permitted in the Work.
  2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.
- F. Sleeve anchors:
  1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Sleeve Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
1/2 inch	2 3/4 inch	Not accepted	8 inch
5/8 inch	3 inch	Not accepted	10 inch
3/4 inch	3 1/4 inch	Not accepted	12 inch

2. Install with the sleeve fully engaged in the base material.
- G. Screw anchors:
  1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:





Screw Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2 1/2 inch	3 1/4 inch	8 inch
1/2 inch	3 1/4 inch	4 1/2 inch	8 inch
5/8 inch	4 inch	5 inch	10 inch
3/4 inch	5 1/2 inch	6 1/4 inch	12 inch

2. Install screw anchors using equipment and methods recommended by the manufacturer. Continue driving into hole until the washer head is flush against the item being fastened.

H. Undercut concrete anchors:

1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Undercut Anchors			
Nominal Diameter (bolt)	Minimum Effective Embedment Length		Minimum Member Thickness <sup>(1)</sup>
	In Concrete	In Grouted Masonry	
3/8 inch	4 inch	Not accepted	8 inch
1/2 inch	5 inch	Not accepted	14 inch
5/8 inch	7 1/2 inch	Not accepted	18 inch
7/8 inch	10 inch	Not accepted	20 inch
Note: (1) Thickness indicated is for pre-set units. If through-set units are accepted, obtain minimum member thickness requirements from the Engineer.			

2. Installations of undercut anchors shall not be allowed where edge distances are less than 12 times the nominal diameter of the anchor stud.
3. Undercut bottom of hole using cutting tools manufactured for this purpose by the manufacturer of the undercut anchors being placed.

### 3.06 FIELD QUALITY CONTROL

- A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450 - Quality Control.
  1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.
- B. Post-installed anchors:
  1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.



2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

### **3.07 FIELD QUALITY ASSURANCE**

- A. Owner or Owner's Representative will provide on-site observation and field quality assurance for the Work of this Section.
  1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.
- B. Field inspections and special inspections:
  1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.
  2. Record of inspections:
    - a. Maintain record of each inspection.
    - b. Submit copies to Engineer upon request.
  3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.
- C. Special inspections: Anchors cast into concrete and built into masonry.
  1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
    - a. Anchor bolts.
    - b. Anchor rods.
    - c. Concrete inserts (all types).
    - d. Deformed bar anchors.
    - e. Welded studs.
  2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
    - a. Anchor:
      - 1) Type and dimensions.
      - 2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
      - 3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
      - 4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
  3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
    - a. Base material (concrete or grouted masonry):
      - 1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.



2) Material encapsulating embedment is dense and well-consolidated.

- D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
1. Provide special inspection during installation of the following anchors:
    - a. Concrete anchors.
    - b. Sleeve anchors.
    - c. Screw anchors.
    - d. Undercut concrete anchors.
  2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
    - a. Provide continuous special inspection for post-installed anchors in “overhead installations” as defined in this Section.
  3. Requirements for periodic special inspection:
    - a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
      - 1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new “initial inspection.”
    - b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor’s rated strength.
    - c. Anchor:
      - 1) Manufacturer, type, and dimensions (diameter and length).
      - 2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
    - d. Hole:
      - 1) Positioning: Spacing and edge distances.
      - 2) Drill bit type and diameter.
      - 3) Diameter, and depth.
      - 4) Hole cleaned in accordance with manufacturer’s required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
      - 5) Anchor’s minimum effective embedment.
      - 6) Anchor tightening/installation torque.
  4. Requirements for continuous special inspection:
    - a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.
- E. Field tests:
1. Owner or Owner’s Representative may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
    - a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
    - b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.



### 3.08 NON-CONFORMING WORK

- A. Remove misaligned or non-performing anchors.
- B. Fill empty anchor holes and repair failed anchor locations using high-strength, non-shrink, non-metallic grout.

### 3.09 SCHEDULES

- A. Provide and install anchor materials as scheduled in the following Table.

Table - Required Anchoring Materials by Location			
Location/Exposure		Materials	Notes
1.	<b>Anchors into concrete and grouted masonry for attachment of carbon steel, including structural steel and other steel fabrications:</b>		
a)	Interior dry areas	Carbon steel - galvanized	
b)	Locations with galvanized steel structures or fabrications	Stainless steel - Type 316	1
c)	Exterior and interior wet and moist locations	Stainless steel - Type 316	1
d)	Corrosive locations	Stainless steel - Type 316	1
2.	<b>Anchors into concrete and grouted masonry for attachment of aluminum, stainless steel, or fiber-reinforced plastic (FRP) shapes and fabrications:</b>		
a)	Interior dry areas	Stainless steel - Type 316	1
b)	Exterior and interior wet and moist locations	Stainless steel - Type 316	1
c)	Corrosive locations	Stainless steel - Type 316	1
3.	<b>Anchors for attaching equipment and its appurtenances:</b>		
a)	All locations	Stainless steel - Type 316 (unless Type 304 is specifically indicated in the specifications for the equipment.)	1
<u>Note:</u> (1) Where anchors are in contact with a metal that differs from that of the anchor, provide isolation sleeves and washers.			

END OF SECTION



## SECTION 05216

### OPEN WEB STEEL JOIST FRAMING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Open web steel joists, joist girders, and accessories.
  - 2. Welding and bolts for connections at joists and joist girders.

##### 1.02 REFERENCES

- A. American Welding Society (AWS):
  - 1. A2.4 - Standard Symbols for Welding, Brazing, and Non-Destructive Examination.
  - 2. B2.1 - Specification for Welding Procedure and Performance Qualification.
  - 3. D1.1 - Structural Welding Code - Steel.
- B. ASTM International (ASTM):
  - 1. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  - 2. F436 - Standard Specification for Hardened Steel Washers.
  - 3. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- C. Occupational Safety and Health Administration (OSHA):
  - 1. Code of Federal Regulations, Title 29 – Labor, Chapter XVII.
    - a. Part 1926.757 - Steel Erection; Open Web Steel Joists.
- D. Society for Protective Coatings (SSPC):
  - 1. Paint 15 - Steel Joist Shop Primer/Metal Building Primer.
  - 2. SP-15 - Commercial Grade Power tool Cleaning.
- E. Steel Joist Institute (SJI):
  - 1. Code of Standard Practice:
    - a. COSP - Code of Standard Practice for Steel Joists and Joist Girders.
  - 2. Standard Specifications:
    - a. K Series - Standard Specifications for Open Web Steel Joists.
    - b. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
    - c. JG Series - Standard Specification for Joist Girders.
  - 3. Standard Load Tables:
    - a. Standard Specification Load Tables and Weight Tables for Steel Joists and Joists Girders.
  - 4. Technical Digests:
    - a. TD 8 - Welding of Open-Web Steel Joists and Joist Girders.
    - b. TD 9 - Handling and Erection of Steel Joists and Joist Girders.



03

## DEFINITIONS

- A. Steel joists: As referred to in this Section, includes joists, K series joist substitutes, joist girders, and joist headers.
- B. SJI Standard Specifications: Refers to one or more of the following documents corresponding to the joist type indicated on the Drawings:
  - 1. K Series - Standard Specifications for Open Web Steel Joists.
  - 2. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
  - 3. JG Series - Standard Specification for Joist Girders.
- C. SJI Standard Load Tables: Refers to one of the following documents corresponding to the joist type indicated on the Drawings:
  - 1. Standard Load Tables, Open Web Steel Joists, K-Series (LRFD & ASD).
  - 2. Standard Load Tables, Longspan Steel Joists, LH-Series (LRFD and ASD).
  - 3. Standard Load Tables, Deep Longspan Steel Joists, DLH Series (LRFD and ASD).

## 1.04 SUBMITTALS

- A. General: Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. Manufacturer's specifications and installation instructions for each type of joist and accessories.
  - 2. Coatings:
    - a. Shop coating. Manufacturer's product data sheets indicating type and characteristics of applied coatings, and recommendations for preparation and materials for finished coatings.
- C. Shop drawings:
  - 1. General:
    - a. Provide fabrication drawings/schedules, and erection/layout drawings for all joists and related miscellaneous metal work.
    - b. Clearly indicate portion of the Work covered by each submittal, and location of each member in the work.
    - c. Mark number or tags on joists and fabrications shall be the same mark numbers indicated on fabrication schedules and erection drawings.
    - d. Indicate shop and field welds using symbols in accordance with AWS A2.4. Indicate net weld lengths.
  - 2. Fabrication drawings/schedules:
    - a. Detail each piece or assembly to be incorporated into the work.
    - b. For each joist type and size, and for each accessory, indicate:
      - 1) SJI standard designations including depth and chord size.
      - 2) Identification mark number.
      - 3) Loading criteria and camber.
      - 4) Configuration and details including joist elevation view; bearing seats; end conditions; chord extensions; and details of internal joints, welds, and splices (if any).
      - 5) Dimensions, both overall and internal.
      - 6) Methods of connecting, anchoring, fastening, bracing, bridging, and attaching.



- 7) Coatings and surface preparation.
3. Erection/layout drawings:
  - a. Indicate placement of each piece shown in the fabrication drawings/schedules or listed in the bill of materials.
  - b. Show layout of joists with mark numbers; methods of framing at openings; locations, types, and connection details for bridging; details of connections between joists and supporting joist girders, joist headers, framing, or structures; and accessories.
  - c. Indicate erection sequence and requirements for temporary bracing.
  - d. Show requirements for field welding and bolting.
  - e. Show profiles and deflection criteria under live and total loads for joist configurations not specifically listed in SJI Standard Load Tables.
  - f. List loads used in the design of steel joists.
    - 1) Show loads and position of loads from all mechanical and electrical equipment supported by the joists and framing.
- D. Calculations:
  1. Submit calculations for each joist type and span, documenting adequacy to resist uniform and concentrated loads indicated on the Drawings; locations, sizes and types of bridging for resisting downward and uplift loads; and adequacy of connections of joists and bridging.
  2. Provide calculation cover letter sealed and signed by the joist manufacturer's qualified registered design professional licensed in the state where the Project is located.
- E. Certificates/certifications:
  1. SJI membership. Submit evidence of manufacturer's current membership in SJI and of manufacturer's qualifications to produce members of the types specified and required for the Work.
  2. SJI compliance. At the completion of manufacturer, for each joist type and load case provided, submit manufacturer's certificate of compliance stating that design and fabrication of members was performed in accordance with SJI Standard Specifications and the approved shop drawings. Include manufacturer's statements that:
    - a. Welders performing shop welding for joists hold current qualification for the types of welding and welding positions required for the Work.
    - b. Manufacturer has completed in-plant before shipment to verify compliance of materials and workmanship with the requirements of SJI Standard Specifications for the products produced.
  3. Quality control program: Submit evidence of active participation in a nationally recognized program for quality control of steel fabrication.
  4. Field welding. Submit welder qualification certificates in accordance with AWS D1.1 for the types of welding and welding positions required for the Work.
- F. Test and inspection reports:
  1. Mill test reports: Submit manufacturer's certificates, indicating ASTM standards, structural strength, and material properties for steel used in the joists and bridging.





2. Inspections:
  - a. Source quality control.
    - 1) Submit reports of manufacturer's in-plant inspections for compliance with SJI Standard Specifications.
  - b. Field quality control:
    - 1) Report of erection inspection.
    - 2) Report of welding inspection.

## 1.05 SYSTEM DESCRIPTION

- A. Pre-engineered, pre-fabricated open-web steel joists, joist girders, and accessories designed and fabricated to the requirements of the Steel Joist Institute and details as specified in this Section and indicated on the Drawings.
- B. Design requirements:
  1. Design joists and bridging in accordance with current SJI Specifications and load tables to support loads indicated based on the depth, spacing, and deflections, indicated.
    - a. Maximum deflection under live load:
      - 1) Roof joists: Span divided by 240 .
    - b. Minimum design loads as indicated on the Drawings:
      - 1) Dead load.
      - 2) Live load.
      - 3) Snow load.
      - 4) Wind load (net uplift).
      - 5) Axial tension and compression forces applied to the truss at end connections.
    - c. Camber: Provide standard camber based on SJI Standard Specifications unless otherwise indicated on the Drawings.
      - 1) In no case shall joists be manufactured with negative (downward) camber.
  2. Bridging: Provide horizontal and diagonal bridging as required by the SJI Standard Specifications, as indicated on the Drawings, and as required to maintain stability under gravity, uplift, erection, and construction loadings.
  3. End anchorage: Provide end anchorage details to secure and/or stabilize joists at supports, and to transfer any loads indicated on the Drawings.
  4. Header units: Provide header units to support joists at openings in floor or roof framing not framed with structural steel shapes.
  5. Accessories:
    - a. Provide miscellaneous items including splice plates, reinforcing angles, and bolts required to complete the installation.
    - b. Provide supplemental steel framing to support steel deck where normal deck bearing is precluded by other framing members and minor openings.

## 1.06 QUALITY ASSURANCE

- A. Design and fabricate joists in compliance with the following and as specified in this Section:
  1. SJI Standard Specifications.
  2. SJI Standard Load Tables.
  3. SJI Code of Standard Practice.



- B. Qualifications:
  - 1. Manufacturers:
    - a. Holding current membership in the Steel Joist Institute and a recognized fabricator of structural steel joists conforming to the SJI Standard Specifications, the SJI Standard Load Tables, and the SJI Code of Practice.
  - 2. Installer/Erector:
    - a. Field Welding: Qualified procedures and welders in accordance with AWS D1.1. Provide welders qualified within the last 12 months preceding the date of joist erection.
- C. Regulatory requirements:
  - 1. In accordance with OSHA requirements for steel erection, including specific requirements for joists and framing.
- D. Inspection:
  - 1. Inspect joists in accordance with SJI Standard Specifications.
  - 2. Inspect fabrication as specified in Part 2, Source Quality Control.
  - 3. Provide inspections for Field Quality Control and Field Quality Assurance as specified in Part 3, Execution.
- E. Pre-installation conference: Steel joists and deck.
  - 1. Coordinate with the requirements of Section 05310 - Steel Deck.
  - 2. Schedule and conduct pre-installation conference at least 2 weeks prior to installation of joists.
    - a. Provide additional conferences if necessary to discuss or coordinate specific conditions of installation.
  - 3. Required attendees:
    - a. Contractor.
    - b. Steel joist manufacturer's technical representative.
    - c. Steel joist installer's job superintendent.
    - d. Subcontractor(s) providing and installing coatings under Division 9.
  - 4. Agenda:
    - a. Joist submittals.
    - b. Deck placing and fastening procedures.
    - c. Manufacturer's recommended inspections and inspection procedures.
    - d. Requirements and coordination for quality control inspections and quality assurance (including special inspections).
    - e. Other Specification requirements requiring coordination between parties to the work.
  - 5. Prepare and submit minutes of the pre-installation conference as specified in Section 01312 - Project Meetings.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Transport, deliver, store, and handle steel joists as recommended in SJI specifications, and as required to avoid stresses and to prevent damage to materials and coatings.
- B. Observe delivered materials for damage before and after unloading, and note any permanent bends, deformations, broken welds, or other damage on the receiving documents.



- C. Store joists off the ground, protected from weather and corrosion, and under watertight covering sloped to drain.
  - 1. Support by means that will protect members from distortion and damage.
  - 2. Store joists with top chord down and with plane of joist vertical.

## **1.08 WARRANTY**

- A. As specified in Section 01783 - Warranties and Bonds.
- B. Special warranty:
  - 1. Duration: 5 years warranty on joists.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Steel joists:
  - 1. Provide joist type, chord configuration, depth, and bearing as indicated on the Drawings.
  - 2. Comply with SJI Standard Specifications for joist series indicated and for joist girders.
  - 3. Details: Provide the following.
    - a. Chord members: Rolled double angle sections only. Rod or bar members are not permitted.
- B. Bridging:
  - 1. In accordance with SJI Standard Specifications for type of joist, chord size, spacings, spans and uplift loads indicated on the Drawings.
  - 2. Anchored to walls, girders, and roof deck as indicated.
- C. Coatings:
  - 1. Shop paint. In accordance with SSPC Paint 15.
- D. Fasteners:
  - 1. Anchor bolts and anchor rods to concrete and masonry: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
  - 2. Bolts: pre-tensioned bolted connections.
    - a. Provide high-strength bolt assembly with hardened flat washers and nuts. Provide uncoated components unless galvanized coating is indicated on the Drawings.
    - b. Uncoated:
      - 1) Bolts: Plain, heavy hex structural bolts conforming to ASTM F3125, Grade A325, Type 1.
      - 2) Nuts: Heavy hex nuts conforming to ASTM A563, Grade C.
      - 3) Washers: Circular flat washers conforming to ASTM F436.
- E. Accessories:
  - 1. Bearing plates: As specified in Section 05120 - Structural Steel and or 05500 - Metal Fabrications.



## **2.02 FABRICATION**

- A. Open web steel joists:
  - 1. Fabricate steel joist in accordance with SJI Standard Specifications to details indicated on the Drawings.
- B. Cross bridging: Provide horizontal or diagonal type bridging for joists.
- C. End anchorage: Provide end anchorage, including bearing plates, to secure joists to adjacent construction as indicated on the Drawings.
- D. Coatings:
  - 1. Shop primer:
    - a. Clean and prime joists and accessories in accordance with SSPC Paint 15.

## **2.03 SOURCE QUALITY CONTROL**

- A. Tests and inspections:
  - 1. Provide joist manufacturer's inspection as required by SJI Standard Specifications. Submit inspection results.
  - 2. Special Inspection - Fabrication. Requirements of the building code specified in Section 01450 - Regulatory Requirements for special inspection of fabricated structural items shall be considered to be satisfied when the manufacturer is registered and approved to perform steel fabrication work in accordance with a quality control program that is certified by the Steel Joist Institute (SJI), the American Institute of Steel Construction (AISC), the City of Los Angeles Department of Building and Safety (COLA), or similar program acceptable to building official and the Engineer.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. Furnish and erect steel joists accordance with the requirements of SJI's Code of Standard Practice for Steel Joists and Joist Girders.

### **3.02 PREPARATION**

- A. Field verify dimensions and elevations of structural elements supporting the joists and joist girders.
  - 1. Establish lines and elevations within tolerances before beginning erection.
  - 2. Make bearing surfaces true and uniform.
  - 3. Do not begin placement of steel joists until supporting work is in place and secured.
- B. Clean bearing surfaces of joists and supporting members before erection and as required during erection to maintain solid contact between members.
- C. Do not permit erection of steel deck until joists are connected and bridging is in place.



## INSTALLATION

### A. Erection:

1. Place and secure steel joists in accordance with SJI Standard Specifications, approved erection drawings, and these Specifications.
2. Allow for loads from erection procedures, but do not load joists until all fastening is complete.
3. Provide sufficient temporary bracing to maintain joists and supporting framing safe, plumb, and in true alignment until completion of erection and installation of permanent bridging and bracing.

### B. Installation of joists and bridging:

1. Do not start placement of steel joists until supporting work is in place, adjusted to specified tolerances, and secured.
2. Do not field modify, alter, or repair joists unless specific written instructions have been received from the joist manufacturer and submitted to the Engineer. Such instructions shall bear the seal and signature of the joist manufacturer's registered design professional licensed in the state where the joists are installed.
3. Place joists on supporting surfaces, adjust, and accurately align to required elevation, location and spacing before permanently fastening.
  - a. Set joists plumb and level (with indicated allowances for camber).
  - b. Set "tag end" of joists at location shown on the erection plans.
  - c. Ensure that "square-end" joists are erected with the right side at the top.
  - d. Adjust bearing shoe elevations to provide full bearing after joists and supporting members have been plumbed and positioned, but before final tightening of connections and before any loads are imposed.
  - e. Solidly pack areas under bearing plates using materials and procedures indicated on the Drawings.
4. Install bridging in accordance with OSHA 29CFR-1926.757d and SJI Standard Specifications to provide lateral stability for the joists before slacking of hoisting lines. Quantity of bolted diagonal erection bridging shall be in accordance with SJI Standard Specifications.
5. Install bridging simultaneously with joist erection and before construction loads are applied. Anchor ends of bridging lines at top and bottom chords where terminating at walls or beams. Quantity, size, and sequence for installing bridging shall be in accordance with SJI Standard Specifications.
6. Erection stability and handling shall be in accordance with SJI Standard Specifications.

### C. Fastening joists:

1. Each joist must be attached at a minimum of one end immediately upon placement in the final erection position and before additional joists are placed.
2. When field welding joists, weld to supporting steel framework in accordance with SJI Standard Specifications and as indicated on the Drawings.
  - a. Coordinate welding sequence and procedure with placing of joists.
  - b. In accordance with AWS D1.1.
  - c. Length of field welds applied to the top and bottom chords of joists shall not exceed 1/2 of the width of the steel member.
3. When bolting joists, bolt to supporting steel framework in accordance with SJI Standard Specifications.



- D. Coating:
1. Deliver joists coated or uncoated as indicated on the Drawings and specified.
  2. Where members are painted or coated in place, do not begin preparation or coating until all units are in place; properly, completely, and permanently fastened, and accepted by the Engineer.
  3. Prepare, prime, and finish as specified in Section 09960 - High-Performance Coatings.
  4. Perform surface preparation and coating application under environmentally controlled field conditions, or in an off-site paint shop.

### **3.04 TOLERANCES**

- A. As indicated in SJI Standard Specifications, unless otherwise noted.
- B. Deviation from straight line between opposite ends of any installed joist: Maximum 3/8 inch in 10 feet.

### **3.05 REPAIR**

- A. Do not install damaged joists or accessories. Remove such materials from the site and replace with sound materials at no additional cost to the Owner.
- B. Repair rust spots and coatings damaged by handling, welding, or other erection and fastening processes.
- C. After erection, touch-up rust spots, connections, field welds, and abraded areas of members using specified coatings. Clean and prepare damaged areas. Apply coating at the same thickness as that applied before erection. Feather edges of repairs to provide a uniform appearance after repair.
1. Clean and prepare surfaces using SSPC-SP 15 procedures.
  2. Apply coating of same product and color as member. Apply primer and finish coat(s).

### **3.06 FIELD QUALITY CONTROL**

- A. Provide field quality control over the Work of this Section as required by Section 01450 - Regulatory Requirements.
- B. Field tests and inspections:
1. High-strength bolting:
    - a. Confirm use of specified bolts and nuts.
    - b. Pre-tensioned connections:
      - 1) Confirm that all plies of the connected elements have been brought into firm contact by the tightened connection.
      - 2) Confirm bolts pretension using turn-of-the nut method, twist-off type tension controlled nut, or direct-tension indicator washer. Do not use calibrated wrench.
  2. Welding - Field welds.
    - a. Perform observations and testing in the presence of the Engineer.
    - b. Visual observation:
      - 1) Visually examine all welds in accordance with AWS D1.1.



- 2) Quality of welds and standards for acceptance shall be in accordance with AWS D1.1, "Visual Inspection Acceptance Criteria" Table.
- c. Test results:
  - 1) Submit records of testing to Engineer within 24 hours after testing.
3. After erection, observe installation for conformance with this specification.

### **3.07 FIELD QUALITY ASSURANCE**

- A. Provide field quality assurance over the Work of this Section as required by Section 01450 - Regulatory Requirements.
- B. Special inspections, special tests and structural observation:
  1. Provide as required by Section 01455 - Special Tests and Inspections.
- C. Field inspections:
  1. Required inspections:
    - a. Observe construction for conformance to the Contract Documents and the accepted Shop Drawings.
      - 1) Confirm that joist and accessory locations and tags (marks) match those indicated on the erection drawings.
      - 2) Confirm that joists are installed in vertical alignment and without lateral sweep.
      - 3) Confirm that joist spacing conforms to erection drawings.
      - 4) Confirm that bridging lines, spacing, and connections/anchoring conform to erection drawings.
    - b. Visually inspect field bolting, including bolt tightness.
    - c. Visually inspect field welding using AWS certified welding inspectors in accordance with AWS D1.1.
      - 1) In accordance with AWS D1.1.
      - 2) Mark welds observed.
  2. Records of inspections:
    - a. Provide record of each inspection.
    - b. Submit copies to Engineer upon request.
- D. Field testing.

### **3.08 NON-CONFORMING WORK**

- A. Remove and replace damaged and non-conforming work to the satisfaction of the Engineer.

END OF SECTION





ELEMENTS INSPECTED	REF <sup>(1)</sup>	CONFORMS?		
		Yes	No	Comments <sup>(2)</sup>
<b>Member Installation:</b>				
Joist and accessory locations, tags, and tagged end locations conform to erection drawings.	1			
Joist spacing conforms to erection drawings.	1			
Joists and accessories are installed in horizontal and vertical alignment and without lateral sweep.	1			
Joist bearing length on supporting members conforms to erection drawings and details.	1a			
Joist and accessory installations conform to specified tolerances.				
<b>Bridging:</b>				
Bridging locations, types (horizontal or diagonal), and member sizes conform to erection drawings.	1b			
Bridging connections to joists conforms to erection drawings.	1b			
Bridging connections to and terminations at ends/walls conforms to erection drawings.	1b			
<b>Field Welding:</b>				
Welds at locations indicated on erection drawings.				
Weld size and length as indicated on erection drawings.	1a			
Quality of welds complies with AWS D1.1 - "Visual Inspection Acceptance Criteria" Table	1a			
<b>(Continued, next page)</b>				
<b>Field Bolting:</b>				
Bolts at locations indicated on erection drawings.	1a			
Bolts, nuts and washers of sizes and materials specified.	1a			
Bolts tightened as specified. All plies of connection have been brought into firm contact.	1a			
<b>Other:</b>				

[illegible]



## **SECTION 05310**

### **STEEL DECKING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Steel deck for floors and roofs, and associated accessories.

##### **1.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- B. American Welding Society (AWS):
  - 1. D1.3 - Structural Welding Code - Sheet Steel.

##### **1.03 SUBMITTALS**

- A. Product data.
- B. Shop drawings.

##### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Storage and protection:
  - 1. Store steel deck at the site stacked on platforms or pallets and covered with tarpaulins or other suitable weathertight covering.
  - 2. Do not use steel deck for storage or working platform.
  - 3. Remove damaged, unlabeled, untagged, rusty, and deteriorated steel deck material from the job site.

#### **PART 2 PRODUCTS**

##### **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. ASC Profiles (Formerly IMSA Building Products and BHP).
  - 2. Verco Manufacturing Co.

##### **2.02 MATERIALS**

- A. Sheet steel: ASTM A653, G 90 minimum coating designation.



## **2.03 FABRICATION**

- A. Steel deck shall be formed:
  - 1. So every sheet is identical and will register perfectly with adjacent sheets.
  - 2. In accordance with building code as specified in Section 01410- Regulatory Requirements.
- B. Decking used with concrete fill shall be deformed to develop composite action between the deck and the concrete.
- C. Furnish minimum gauge, deck thickness, section modulus, moment of inertia, and allowable diaphragm shear per foot of deck width that is not less than for type deck sections indicated on the Drawings.
- D. Treat exposed roof deck with phosphate.
- E. Furnish roof deck ready to receive field painting without further pretreatment. Paint exposed roof deck in accordance with Contract Documents.
- F. Accessories:
  - 1. Furnish all accessories indicated on the Drawings or needed to completed work.
  - 2. Minimum required gauges:
    - a. Sump pans: 14 gauge.
    - b. All other accessories: 20 gauge unless otherwise indicated on the Drawings.
- G. Welding and electrodes: In accordance with AWS D1.3.
- H. Furnish roof decking in lengths to minimize number of splices.
- I. Furnish steel deck complete, including cutting, shaping, fitting, drilling, welding, ridge plates, valley plates, reinforcing plates for openings, and miscellaneous pieces necessary for proper installation.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

### **3.02 INSTALLATION**

- A. Decking shall span over at least 3 spans wherever possible.
- B. Do not damage or overload roof deck during installation.
- C. Do not use steel deck for storage or as a working platform until sheets have been welded in position.



- D. Do not exceed maximum uniformly distributed load of 20 pounds per square foot.
- E. Install decking in straight and continuous rows as far as practicable, with ribs at right angles to supporting members.
- F. For each end of deck section, provide 3 inches minimum bearing on supports. For sections that abut each other, each piece shall bear a minimum of 3 inches on the support. This requires a 6 inch minimum flange width. For cases where the minimum bearing cannot be obtained, notify the Engineer.
- G. Electric arc weld deck sections to bearing plates, supports at butt joints, at intermediate supports, side supports, and at end supports as indicated on the Drawings. Do not burn through the deck. Remove all slag.
- H. Fasten the longitudinal joints between deck sections together by the method indicated on the Drawings.
- I. Neatly cut and fit openings in roof deck, and reinforce with structural steel members as indicated on the Drawings.
- J. Paint welds as specified.
- K. Install roof deck free of dents and bent members.
- L. Reinforce all holes and openings in steel deck as indicated on the Drawings.
- M. Piping, conduit, equipment, and other services: Do not hang from decking.
- N. Install all accessories required to complete work.

### **3.03 REPAIR OF GALVANIZING AND COATING**

- A. Touch-up damage to galvanized surfaces, including cut edges and holes, with zinc rich primer.
- B. Repair damage to factory-applied coating system in accordance with the manufacturer's printed recommendations.

### **3.04 CLEANUP**

- A. After erection, remove weld spatter, grease, and oil from decking.

END OF SECTION





## SECTION 05500

### METAL FABRICATIONS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Aluminum grating stair tread.
  - 2. Aluminum stair nosing.
  - 3. Cast iron stop plank grooves.
  - 4. Concrete inserts.
  - 5. Handrails and guardrails.
  - 6. Ladders.
  - 7. Manhole frames and covers.
  - 8. Manhole steps
  - 9. Metal gratings.
  - 10. Metal tread plate.
  - 11. Preformed channel pipe supports.
  - 12. Stairs.
  - 13. Miscellaneous metals.
  - 14. Associated accessories to the above items.

##### 1.02 REFERENCES

- A. Aluminum Association (AA):
  - 1. DAF-45: Designations from Start to Finish.
    - a. M12-C22-A41.
- B. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. Standard Specifications for Highway Bridges.
- C. ASTM International (ASTM):
  - 1. A36 - Standard Specification for Carbon Structural Steel.
  - 2. A48 - Standard Specification for Gray Iron Castings.
  - 3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
  - 4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
  - 6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
  - 7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
  - 8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  - 9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
  - 10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.





11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
  12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
  13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  14. A992 - Standard Specification for Structural Steel Shapes.
  15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
  16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
  17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
  18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
  19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
  20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- D. American Welding Society (AWS):
1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
- E. National Association of Architectural Metal Manufacturers (NAAMM):
1. Metal Finishes Manual.
- F. Occupational Safety and Health Administration (OSHA).

### **1.03 DEFINITIONS**

- A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

### **1.04 SUBMITTALS**

- A. Product Data:
1. Aluminum grating stair tread.
  2. Aluminum stair nosing.
  3. Cast iron stop plank grooves.
  4. Handrails and guardrails.
  5. Manhole frames and covers.
  6. Manhole steps.
  7. Metal grating.
- B. Shop drawings:
1. Handrails and guardrails:
    - a. Including details on connection attachments, gates, kick plates, ladders, and angles.



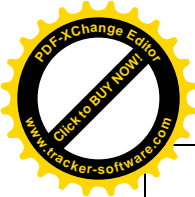
- b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
    - c. Include erection drawings, elevations, and details where applicable.
    - d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
  - 2. Ladders.
  - 3. Metal grating.
  - 4. Metal tread plate.
  - 5. Stairs.
  - 6. Miscellaneous metals.
- C. Samples:
  - 1. Guardrails with specified finishes.
- D. Quality control submittals:
  - 1. Design data.
  - 2. Test reports:
    - a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
    - b. Gratings:
      - 1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
      - 2) Reports of tests performed.
    - c. Planks:
      - 1) Plank manufacturers' calculations showing that planks will meet specified load-bearing and deflection requirements for each size plank for each span.
      - 2) Reports of tests performed.

## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
<b>Cast Iron</b>		
Cast Iron	A48	Class 40B
<b>Steel</b>		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A36	--



Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	--
Tubing, hot-formed	A501	--
Steel pipe	A53	Grade B
<b>Stainless Steel</b>		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
<b>Aluminum</b>		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B209	Alloy 6061-T6
Structural aluminum	B209 B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

## 2.02 MANUFACTURED UNITS

- A. Aluminum grating stair tread:
  1. Manufacturers: One of the following or equal:
    - a. Harsco Industrial IKG, Aluminum Grating Stair Tread with Mebac® nosing.
    - b. McNichols Co., Type A-Standard with Corrugated Angle Nosing.
  2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers.
  3. Size:
    - a. Tread width: To equal tread spacing plus 1 inch minimum.
    - b. Tread length: Length to suit stringer-to-stringer dimension on the Drawings.
    - c. Depth: 1-3/4 inches.



4. Bolts: Type 316 stainless steel.
- B. Aluminum stair nosing:
1. Manufacturers: One of the following or equal:
    - a. Wooster Products, Inc., Type 101 Nosing.
    - b. American Safety Tread Co., Inc., Style 801 Nosing.
  2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
  3. For installation in cast-in-place stairs.
  4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.
- C. Cast iron stop plank grooves:
1. Manufacturers: One of the following or equal:
    - a. Neenah Foundry Co., R-7500 Series, Type A.
    - b. McKinley Iron Works, Type L.
  2. Size: 2-inch wide groove opening by 1-1/2 inch deep, unless otherwise indicated on the Drawings.
  3. Recess groove with the cast iron surface of the groove set flush with the concrete surface.
- D. Concrete inserts:
1. Concrete inserts for supporting pipe and other applications are specified in Section 15061 - Pipe Supports.
- E. Handrails and guardrails:
1. General:
    - a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
    - b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
      - 1) Indicate on the shop drawings locations of such equipment.
      - 2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.
  2. Aluminum handrails and guardrails (nonwelded pipe):
    - a. Rails, posts, and fitting-assembly spacers:
      - 1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
    - b. Kick plates: 6061 or 6105 aluminum alloy.
    - c. Fastenings and fasteners: As recommended or furnished by the manufacturer.
    - d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
      - 1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
        - a) Bases: 6061 or 6063 extruded aluminum alloy.
      - 2) Plug screws or blind rivets: Type 305 stainless steel.
        - a) Other parts: Type 300 series stainless steel.



- e. Finish of aluminum components:
    - 1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    - 2) Pretreat aluminum for cleaning and removing markings before anodizing.
  - f. Fabrication and assembly:
    - 1) Fabricate posts in single, unspliced pipe length.
    - 2) Perform without welding.
    - 3) Do not epoxy bond the parts.
    - 4) Maximum clear opening between assembled railing components as indicated on the Drawings.
  - g. Manufacturers: One of the following or equal:
    - 1) Moultrie Manufacturing Co., Wesrail.
    - 2) Golden Railings, Riveted System.
    - 3) Craneveyor Corp. Enerco Metals, C-V Rail.
  - 3. Steel pipe handrails and guardrails:
    - a. Schedule 40 black steel pipe with minimum 1.9-inch outside diameter, or larger where indicated on the Drawings.
    - b. Fabricate posts in single, unspliced pipe length.
    - c. Kick plates: Galvanized steel.
    - d. Attachment devices: Provide clip angles and other fasteners necessary for securing handrails and guardrails to other construction as indicated on the Drawings.
    - e. Continuously weld joints and grind smooth.
    - f. Bend rails to profile indicated on the Drawings, without sharp bends or flat spots. Rails shall be round after bending.
    - g. Neatly weld intersection of rails and posts, and grind surfaces smooth.
  - 4. Guardrail gates:
    - a. Supplied by guardrail manufacturer:
      - 1) Of same material, quality, and workmanship as specified for guardrail system in which they will be installed.
      - 2) Of design similar to that of handrail or railing system in which they will be installed.
    - b. Components: Gate frame, stainless steel self-closing device, hinges, gate stops, and durable self-locking type latch. Fabricate components in conformance with OSHA minimum strength requirements.
  - 5. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.
- F. Ladders:
- 1. General:
    - a. Type: Safety type conforming to local, State, and OSHA standards as minimum. Furnish guards for ladder wells.
    - b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
  - 2. Aluminum ladders:
    - a. Materials: 6063-T5 aluminum alloy.
    - b. Rungs:
      - 1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.



- 2) Capable of withstanding 1,000 pound load without failure.
  - c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
  - d. Finish of aluminum components:
    - 1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    - 2) Pretreat aluminum for cleaning and removing markings before anodizing.
  - e. Fabrication:
    - 1) Welded construction, of size, shape, location, and details indicated on the Drawings.
    - 2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and OSHA requirements.
  - f. Fall prevention system: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements:
    - 1) Manufacturers: One of the following or equal:
      - a) North Consumer Products, Saf-T-Climb.
      - b) Swager Communications, Climbers Buddy System.
- G. Manhole frames and covers:
  - 1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
  - 2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
  - 3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
  - 4. Frame:
    - a. Bottom flange type.
    - b. Approximately 4-1/2 inches frame height.
    - c. Dimensions as indicated on the Drawings.
      - 1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
  - 5. Cover:
    - a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as "ELECTRICAL," "SEWER," "TELEPHONE," or "WATER."
    - b. Solid type without ventilation holes.
  - 6. Finish: Unpainted.
- H. Manhole steps:
  - 1. Type 316 stainless steel, of size, shape, and spacing indicated on the Drawings.
- I. Metal gratings:
  - 1. General:
    - a. Fabricate grating to cover areas indicated on the Drawings.
    - b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    - c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    - d. Band ends of grating and edges of cutouts in grating:



- 1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
- 2) Cutout banding: Full-height of grating.
- 3) Use banding of same material as grating.
- 4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
- 5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
- 6) Openings smaller than 6 inches: Locate opening at edge of single panel.
- 7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
- 8) Fabricate steel grating sections in units weighing not more than 150 pounds each.
- 9) Fabricate aluminum grating sections in units of weighing not more than 150 pounds each.
- 10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.
- e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
  - 1) Furnish a suitable dial gauge for measuring deflections.
- f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.
2. Aluminum grating:
  - a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
  - b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
  - c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
  - d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
  - e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
  - f. Maximum fiber stress for design load: 12,000 pounds per square inch.
  - g. Maximum deflection due to design load: 1/240 of grating clear span.
  - h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
  - i. Minimum grating height: 1-1/2 inches.
  - j. Manufacturers: The following or equal:
    - 1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.
3. Steel gratings:
  - a. Hot-dip galvanized in accordance with ASTM A123.
  - b. Bar size and spacing: As determined by the manufacturer to support design load.
  - c. Design live load: A minimum of 100 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
  - d. Maximum fiber stress for design load: 18,000 pounds per square inch.
  - e. Maximum deflection under design load: 1/240 of grating clear span.
  - f. Bar spacing: Maximum of 1-1/8 inches clear between bars.
  - g. Manufacturers: The following or equal:





- 1) Harsco Industrial IKG, IKG Weldforged.
4. Heavy-duty steel grating:
  - a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
  - b. Hot-dip galvanized after fabrication in accordance with ASTM A123.
  - c. Manufacturers: One of the following or equal:
    - 1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
    - 2) Seidelhuber Metal Products, Inc., equivalent product.
- J. Metal tread plate:
  1. Plate having a raised figured pattern on 1 surface to provide improved traction.
- K. Preformed channel pipe supports:
  1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 15062 - Preformed Channel Pipe Support System.
- L. Stairs:
  1. Aluminum stairs:
    - a. Stringers: 6061-T6 aluminum alloy.
    - b. Stair treads:
      - 1) Aluminum of same type specified under Aluminum Grating.
      - 2) Of sizes indicated on the Drawings, and 1-3/4 inch minimum depth with cast abrasive type safety nosings.
    - c. Handrails and guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Nonwelded Pipe).
    - d. Fasteners: Type 304 or Type 316 stainless steel.
  2. Steel stairs:
    - a. Ships ladders shall conform to local, State, and OSHA as minimum.
    - b. Stringers: Structural steel channels or plates.
    - c. Treads: Open type attached to stringers with support angles and clips. Manufacturers: One of the following or equal:
      - 1) Harsco Industrial IKG, "Welded Tread" with Algrip® nosing.
    - d. Railings: Steel pipe, sized as indicated on the Drawings.
    - e. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
    - f. Finish: Prime paint finish for interior locations.
- M. Miscellaneous aluminum:
  1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
  2. Do not weld or flame cut.
- N. Miscellaneous cast iron:
  1. General:
    - a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
    - b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
    - c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.



- O. Miscellaneous stainless steel:
1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
    - a. Fabricate and install in accordance with the best practices of the trade.
  2. Cleaning and passivation:
    - a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
    - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
    - c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
      - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
    - d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
      - 1) Passivation by citric acid treatment is not allowed.
        - a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
      - 2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
      - 3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
    - e. After cleaning, inspect using methods specified for "gross inspection" in ASTM A380.
    - f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.
- P. Miscellaneous structural steel:
1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
    - a. Fabricate and install in accordance with the best practices of the trade.
- Q. Isolating sleeves and washers:
1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions:
1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
  2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.



## 3.02 INSTALLATION

- A. General:
  - 1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
  - 2. Interface between materials:
    - a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
      - 1) Make application so that the isolating or protective barrier is not visible in the completed construction.
      - 2) Isolating sleeves and washers: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    - b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09960 - High Performance Coatings.
    - c. Aluminum in contact with concrete or masonry.
- B. Aluminum stair nosing:
  - 1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
  - 2. Omit stair nosings where concrete is submerged.
  - 3. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step.
- C. Cast iron stop plank grooves:
  - 1. Recess stop plank grooves with cast iron surfaces of groove set flush with concrete surface.
- D. Handrails and guardrails:
  - 1. General:
    - a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
    - b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
    - c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
    - d. Space attachment brackets as indicated in the manufacturer's instructions.
  - 2. Aluminum pipe handrails and guardrails:
    - a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.
    - b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
    - c. Discontinue handrails and guardrails at lighting fixtures.
    - d. Provide 1/8-inch diameter weep hole at base of each post.
    - e. Space posts as indicated on the Drawings.
    - f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
    - g. Space rails as indicated on the Drawings.



- h. Make adequate provision for expansion and contraction of kick plates and rails.
            - 1) Make provisions for removable sections where indicated on the Drawings.
          - i. Make lower rails a single, unspliced length between posts, or continuous.
          - j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
          - k. Draw up fasteners tight with hand wrench or screw driver.
          - l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
          - m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
          - n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
          - o. Replace damaged or disfigured handrails and guardrails with new.
          - p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
            - 1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
          - q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.
  - 3. Steel pipe handrail and guardrail:
    - a. Anchor posts into concrete by grouting posts into galvanized steel sleeves embedded in concrete as indicated on the Drawings.
      - 1) Do not cut reinforcing bars in concrete.
      - 2) Where required to fasten guardrail to other construction, fasten as indicated on the Drawings.
  - 4. Guardrail gates:
    - a. Install gate to be a vertical plane with the guardrail when in the closed position.
    - b. Install hinges so that each gate can swing 180 degrees from the closed position to the fully open position.
    - c. Install so that the gates swing to the walkway side of the guardrail only.
      - 1) Install gate stops on the stationary railing posts to prohibit gates from swinging in the wrong direction.
    - d. Install gate frames, hinges, stops, and latches in conformance with OSHA minimum strength requirements.
- E. Ladders:
- 1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
  - 2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
  - 3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
  - 4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
    - a. Correct deviations from true line or grade which are visible to the eye.



- F. Manhole frames and covers:
  - 1. Installation: As specified in Section 02084 - Precast Drainage Structures.
- G. Manhole steps:
  - 1. Space as indicated on the Drawings.
- H. Metal gratings:
  - 1. General:
    - a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
    - b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
    - c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
    - d. Install angle stops at ends of grating.
    - e. Installed grating shall not slide out of rebate or off support.
    - f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
    - g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
  - 2. Aluminum grating:
    - a. Aluminum grating: Support on aluminum shelf angles or rebates.
  - 3. Steel grating:
    - a. Support on hot-dip galvanized structural steel shelf angles or rebates.
  - 4. Heavy-duty steel grating:
    - a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
    - b. Use for roadways, traffic areas, and where indicated on the Drawings.
- I. Stairs:
  - 1. General:
    - a. Install guard railings around stair wells as indicated on the Drawings or specified.
- J. Stainless Steel:
  - 1. Welding:
    - a. Passivate field-welded surfaces:
      - 1) Provide cleaning, pickling and passivating as specified in this Section.
      - 2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION





## SECTION 09960

### HIGH-PERFORMANCE COATINGS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
1. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
  2. D2200 – Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
  3. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
  4. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
  5. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
  6. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
  7. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
  8. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
  9. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
  10. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
  11. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
  12. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
  13. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
  14. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
  15. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
  16. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.
- B. International Concrete Repair Institute (ICRI):
1. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

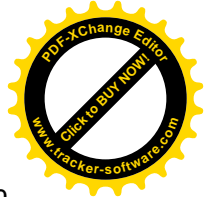




- C. NACE International (NACE):
  - 1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
  - 2. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
- D. National Association of Pipe Fabricators (NAPF):
  - 1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
- E. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.
- F. Occupational Safety and Health Administration (OSHA).
- G. Society of Protective Coatings (SSPC):
  - 1. Glossary - SSPC Protective Coatings Glossary.
  - 2. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
  - 3. Guide 15 - Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
  - 4. PA 1 - Shop, Field, and Maintenance Painting of Steel.
  - 5. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
  - 6. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
  - 7. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
  - 8. SP 1 - Solvent Cleaning.
  - 9. SP 3 - Power Tool Cleaning.
  - 10. SP 5 - White Metal Blast Cleaning.
  - 11. SP 10 - Near-White Metal Blast Cleaning.
  - 12. SP 11 - Power Tools Cleaning to Bare Metal.
  - 13. SP 13 - Surface Preparation of Concrete.
  - 14. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
  - 15. SP COM - Surface Preparation Commentary.
  - 16. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
  - 17. SP WJ-1 - Waterjet Cleaning of Metals -- Clean to Bare Substrate.
  - 18. SP WJ-2 - Waterjet Cleaning of Metals -- Very Thorough Cleaning.
  - 19. SP WJ-3 - Waterjet Cleaning of Metals -- Thorough Cleaning.
  - 20. SP WJ-4 - Waterjet Cleaning of Metals -- Light Cleaning.

### 1.03 DEFINITIONS

- A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.
- B. Specific definitions:
  - 1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
  - 2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.



3. Anchor Pattern: Profile or texture of prepared surface(s).
4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
6. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
7. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
8. Dew point: Temperature a given air/water vapor mixture starts to condense.
9. Drying Time: Time interval between application and material curing.
10. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
11. Dry to Touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
12. Exposed Surface: Any indoor or outdoor surface not buried or encased.
13. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
14. Feathering: Tapering off a wet edge with a comparatively dry brush.
15. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
16. Field Coat: Application of a surface coating system at the work site.
17. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
18. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
20. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
21. Hydroblast: High or ultra-high pressure water jet surface preparation.
22. Incompatibility: One coating's inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
23. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
24. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
25. Mil: 0.001 inch.
26. Overspray: Dry spray, particularly paint bonded to an unintended surface.
27. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
28. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
29. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.



30. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
31. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
32. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
33. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
34. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
35. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
36. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

#### **1.04 ABBREVIATIONS**

- A. CSM - Coating System Manufacturer.
- B. CMU - Concrete Masonry Units.
- C. CSA - Coating System Applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.
- D. CTR - Coating System Manufacturer's Technical Representative.
- E. DFT - Dry-Film Thickness. Thickness of cured film, usually expressed in mils (0.001 inch).
- F. SSD - Surface Saturated Dry. Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.
- G. TPC - Technical Practice Committee.
- H. VOC - Volatile Organic Compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.



- I. WFT - Wet Film Thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

## **1.05 PERFORMANCE REQUIREMENTS**

- A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.
- B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

## **1.06 SUBMITTALS**

- A. As specified in Section 01330 - Submittal Procedures, submit the following:
  - 1. Schedule of proposed coating materials.
  - 2. Schedule of surfaces to be coated with each coating material.
  - 3. Dehumidification and heating plan.
  - 4. Product data:
    - a. Physical properties of coatings, including the following:
      - 1) Solids content.
      - 2) Ingredient analysis.
      - 3) VOC content.
      - 4) Temperature resistance.
      - 5) Typical exposures and limitations.
      - 6) Manufacturer's standard color chips.
    - b. Compliance with regulatory requirements:
      - 1) VOC limitations.
      - 2) Lead compounds and polychlorinated biphenyls.
      - 3) Abrasives and abrasive blast cleaning techniques and disposal.
      - 4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
      - 5) NSF certification of coatings for potable water supply systems.
    - c. CSM's current printed recommendations and product data sheets for coating systems, including:
      - 1) Surface preparation recommendations.
      - 2) Primer type.
      - 3) Maximum dry and wet-mil thickness per coat and number of coats.
        - a) Coating Coverage Worksheets.
      - 4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
      - 5) Curing time before submergence in liquid.
      - 6) Thinner to be used for each coating.
      - 7) Ventilation requirements.
      - 8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
      - 9) Allowable application methods.
      - 10) Maximum allowable substrate moisture content.
      - 11) Maximum shelf life.
      - 12) Requirements for transportation and storage.
      - 13) Mixing instructions.
      - 14) Shelf life.
      - 15) Material Pot life.



- 16) Precautions for applications free of defects.
- 17) Method of application.
- 18) Drying time of each coat, including prime coat.
- 19) Compatible prime coats.
- 20) Limits of ambient conditions during and after application.
- 21) Required protection from sun, wind, and other conditions.
- 22) Touch-up requirements and limitations.
- 23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.
- d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
- e. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
- f. List of cleaning and thinner solutions allowed by the CSMs.
- g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
- h. Thick film coating systems (greater than 25 mils):
  - 1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
  - 2) Include detail treatment for coating system at concrete joints.
  - 3) Manufacturer's Representative's (CTR) Field Reports.
5. Quality assurance submittals:
  - a. Quality assurance plan.
  - b. Qualifications of CSA, including:
    - 1) List of Similar Projects.
      - a) Name and address of project.
      - b) Year of installation.
      - c) Year placed in operation.
      - d) Point of contact: Name and phone number.
    - 2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
  - c. CSA Reports:
    - 1) Written daily quality control inspection reports.
  - d. CTR Reports:
    - 1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
    - 2) Reports on visits to project site to observe and approve coating application procedures.
    - 3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

## 1.07 QUALITY ASSURANCE

- A. CSA qualifications:
  1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:



- a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
  2. SSPC QP 1 certified.
  3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.
- B. CTR qualifications:
  1. Certification, one of the following:
    - a. NACE Level 2 or 3 Certified Coating Inspector.
    - b. SSPC Level 3 Protective Coatings Inspector.
  2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
    - a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.
- C. Regulatory requirements: Comply with governing agencies' regulations by using coatings conforming to their VOC limits.
  1. Lead-based coatings are not permitted.
  2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.
- D. Certification:
  1. Certify that applicable pigments resist deterioration when exposed to hydrogen sulfide and other sewage gases.
  2. Product data shall designate coating as being suitable for wastewater service.
- E. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.
  1. Coordinate Hold Point schedule
- F. Field samples:
  1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
  2. Approved field sample may be part of the Work.
- G. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.
- H. CSM services:
  1. CSA shall arrange for CTR to attend pre-installation conferences.
  2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
  3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
  4. CTR shall provide written inspection reports.
- I. Quality control requirements:
  1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
    - a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor's responsibilities.





2. Conform to this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
3. Specially trained crews with experience applying the specified coating system coating are required for:
  - a. Coating application using plural component spray equipment or other specialty equipment.
  - b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
4. CTR shall specially train personnel for coating systems as specified in Appendix B Coating Detail Sheets.
  - a. CSM shall approve personnel in writing applying the coating system.
5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
6. Identify inspection access points used by Owners or Engineers.
7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer's personnel to safely access the work areas.
8. Conduct and continually inspect work so the coating system is installed as specified. The CSM shall provide written directions to correct coating work not conforming to the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
  - a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
    - 1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    - 2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
  - b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
    - 1) ASTM D4262.
    - 2) ASTM D4263.
    - 3) ASTM D4417.
    - 4) ICRI 310.2 requirements.
    - 5) SSPC Surface Preparation Standards.
  - c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
  - d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
  - e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
  - f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc. during coating.
    - 1) Perform WFT measurements in accordance with ASTM D4414.





- g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces. Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM's written instructions. Perform all applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

J. Inspection at Hold Points:

1. Conduct inspections at Hold Points during the coating system application and record the results.
2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor's inspections on a scheduled basis.
3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
4. Hold Points shall be as follows:
  - a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
  - b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
  - c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
  - d. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
    - 1) Observe conditions during the Pre-application Meeting.

## **1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING**

- A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.
- B. Immediately remove unspecified and unapproved coatings from Project site.
- C. Deliver new labeled, unopened containers:
  1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations.
    - a. Store flammable materials in accordance with federal, state, and local requirements.
    - b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
  2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.



3. Container labels shall show the following:
  - a. Brand name or product title.
  - b. CSM's batch number.
  - c. CSM's manufacture date.
  - d. CSM's name.
  - e. Generic material type.
  - f. Application and mixing instructions.
  - g. Hazardous material identification label.
  - h. Shelf life expiration date.
  - i. Color.
  - j. Mixing and reducing instructions.
4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

## 1.09 PROJECT CONDITIONS

- A. Apply coatings to dry surfaces.
  1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section.
    - a. Plaster and gypsum wallboard: 12 percent.
    - b. Masonry and concrete block: 12 percent.
    - c. Interior located wood: 15 percent.
    - d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
    - e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.
- B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
  1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
  2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
  3. When ambient or surface temperature:
    - a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
    - b. Is less than 65 degrees Fahrenheit for clear finishes, unless manufacturer allows a lower temperature.
    - c. Exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
    - d. Exceeds manufacturer's recommendation.
  4. When relative humidity is higher than 85 percent.
  5. Under dusty or adverse environmental conditions.
  6. When light on surfaces measures less than 15 foot-candles.
  7. When wind speed exceeds 15 miles per hour.



- C. Apply coating only under evaporation conditions rather than condensation.
  - 1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
  - 2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
    - a. Submit test results.
- D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
  - 1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
  - 2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
  - 3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
  - 4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
  - 5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
    - a. Entire curing period.
    - b. 8 hours after coating.
- E. Systems:
  - 1. Site electrical power availability as specified in Section 01500 - Temporary Facilities and Controls.
  - 2. Internal combustion engine generators may be used.
    - a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
    - b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
    - c. Locate engine generator outside hazardous classified areas per NFPA 820.
    - d. Provide daily fuel service for generator for duration of use.
  - 3. Dehumidification:
    - a. Provide desiccant or refrigeration drying.
    - b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
    - c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
  - 4. Heating:
    - a. Use electric, indirect combustion, or steam coil.
    - b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
  - 5. Filters:
    - a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
    - b. Do not allow air from the working area or dust filtration equipment to recirculate through the dehumidifier during coating application or when solvent vapors are present.



6. Design and submittals:
  - a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
  - b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.
- F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

## **1.10 MAINTENANCE**

- A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

## **1.11 CTR RESPONSIBILITIES**

- A. General:
  1. Attend pre-installation conference.
  2. Perform onsite application training.
  3. Periodically inspect coating system application.
- B. Coating system installation training:
  1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
    - a. Train a minimum of 2 supervisory personnel and 2 application personnel.
    - b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
  2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
  3. Minimum training requirements:
    - a. Explain in detail the mixing, application, curing, and termination requirements.
    - b. Provide hands-on demonstration of coating system mixing.
    - c. Explain in detail the ambient condition requirements for temperature and humidity.
    - d. Explain in detail the surface preparation requirements.
    - e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
    - f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
  4. Provide special training as specified in the Coating Detail Sheets.
- C. Coating system inspection:
  1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
  2. Be on-site to oversee:
    - a. Coating application at least once a week.
    - b. End of surface preparation.
    - c. During coating application.
    - d. Post-cure inspection.



3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
4. Perform the following activities to confirm conformance with the specifications:
  - a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
  - b. Inspect each coated surface type and coating system applied to verify the following:
    - 1) Cleanliness.
    - 2) Surface pH for concrete substrates.
    - 3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
  - c. Verify surface profile of substrates by completing the following:
    - 1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
    - 2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
    - 3) Verify proper mixing of coating materials.
    - 4) Inspect application of primers and finish coats, including wet and dry film thickness.
    - 5) Inspect coating systems for proper cure times and conditions.
  - d. Review adhesion testing of cured coating systems.
  - e. Review coating system continuity testing.
  - f. Inspect and record representative-localized repairs.
  - g. Conduct final review of completed coating system installation.
  - h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM's Recommendations.

D. Final report:

1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits. Include a statement that completed work was performed in accordance with the requirements of the CSM's recommendations.

## **PART 2 PRODUCTS**

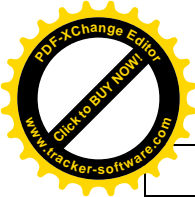
### **2.01 MATERIALS**

A. General:

1. Product requirements as specified in Section 01600 - Product Requirements.

### **2.02 COATING SYSTEMS IDENTIFICATION**

- A. Naming Conventions: Coating Systems Identifications contain the elements defined in Table 1.



**Table 1 Coating System Identification Elements**

First Element	-	Second Element	-	Third Element	-	Fourth Element (optional)
3 or 4 alpha characters		1-3 alpha characters		1 number		3 or 4 alpha characters
Coating Type		Substrate		System Number		Additional Substrate or Special Condition
Example: EPX	-	C	-	6	-	BSC

- 1) First element identifies the coating type using the following abbreviations:
  - a) ACR: acrylic.
  - b) CTE: coal tar epoxy.
  - c) ELA: elastomeric acrylic.
  - d) EPU: epoxy-polyurethane.
  - e) EPX: epoxy.
  - f) POL: polyurethane.
  - g) SIL: silicone.
  - h) SILX: siloxane or silane.
  - i) VE: vinyl ester.
- 2) Second element identifies the substrate using the following abbreviations:
  - a) C: concrete or masonry.
  - b) F: concrete flooring.
  - c) FRP: fiber-reinforced plastic.
  - d) GM: galvanized metal.
  - e) M: metal.
  - f) PVC: polyvinyl chloride, chlorinated polyvinyl chloride.
- 3) Third element identifies the sequential system number.
  - a) For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
- 4) Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
  - a) PWS: Potable water service applications (NSF-61 approved).
  - b) BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
  - c) BG: Below grade or buried.
  - d) OZ: Organic zinc primer, epoxy polyurethane system.
  - e) SC: Secondary containment.

## 2.03 PRODUCTS FOR COATING SYSTEMS

- A. Products: As specified in Appendix B Coating Detail Sheets.
- B. Cleaning solvents:
  1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
    - a. Emulsifying type.
    - b. Containing no phosphates.
    - c. Biodegradable.
    - d. Does not damage zinc.



- e. Compatible with the specified primer.
  - f. Complying with applicable air-quality control board requirements.
2. Use clean white cloths and clean fluids in solvent cleaning.

## **PART 3 EXECUTION**

### **3.01 GENERAL PROTECTION REQUIREMENTS**

- A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.
- B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.
- C. Mask off surfaces of items not to be coated or remove items from area.
- D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.
- E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.
- F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application. Carefully store, clean, and replace items after completing coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.
- G. Erect and maintain protective enclosures in accordance with SSPC- Guide 6.
- H. Protect the following surfaces from abrasive blasting by masking or by other means:
  1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
  2. Machined surfaces for sliding contact.
  3. Surfaces to be assembled against gaskets.
  4. Surfaces of shafting where sprockets will be fit.
  5. Surfaces of shafting where bearings will be fit.
  6. Machined bronze surfaces, including slide gates.
  7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
  8. Galvanized items, unless scheduled to be coated.
- I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.





- J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
  2. After completing coating, reinstall removed items.
  3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

### **3.02 GENERAL SURFACE PREPARATION REQUIREMENTS**

- A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.
- B. Coating detail sheets in Appendix B include additional surface preparation requirements.
- C. Follow more stringent requirement if information conflicts.
- D. Where required by the Owner's representative, a NACE International certified coatings inspector, provided by the Engineer, will inspect and approve surfaces to be coated before applying a coating.
1. CSA shall coordinate coating inspections.
    - a. Identify coating inspection Hold Points during the pre-installation conference.
    - b. Provide at least 2 days notice before inspection.
  2. Contractor shall correct surface defects identified by the inspector at no additional cost to Owner.

### **3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION**

- A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 - Equipment Identification, Section 15076 - Pipe Identification, and Section 16075 - Identification for Electrical Systems.
- B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.
- C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the Owner.
- D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.
- E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.
- F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.



- G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.
- H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.
- I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.
- J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

### **3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES**

- A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
  - 1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
  - 2. Manufacturers: The following or equal:
    - a. CHLOR\*RID International, Inc.
      - 1) Complete soluble salt removal with steam or warm water cleaning.
  - 3. Steam clean and degrease surfaces to be coated to remove oils and grease.
  - 4. Clean surfaces with decontamination agent in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing, as approved by the CTR and the Engineer.
  - 5. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
  - 6. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

### **3.05 BLAST CLEANING**

- A. Surface preparation requirements:
  - 1. Do not reuse spent blast abrasive.
  - 2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
  - 3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
  - 4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.
  - 5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
  - 6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.



7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
  8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.
- B. Water jetting or water blasting:
1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
  2. Perform water jetting or water blasting in accordance with SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

### **3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES**

- A. Cure for at least 28 days before coating.
- B. Remove degraded concrete using abrasive blast cleaning or high or ultrahigh pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove all bruised or cracked concrete.
- C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges per the CSM's recommendations and as indicated on the Drawings.
1. Prepare concrete surfaces in accordance with SSPC-SP 13.
- D. Prepare concrete surfaces in accordance with SSPC-SP 13.
1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
  2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
  3. Repair concrete defects and physical damage.
  4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
  5. Fill voids to provide surface as specified in Section 03366 - Tooled Concrete Finishing.
- E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
  2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
- F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.



2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.
- G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.
- H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.
- I. Vacuum all concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
  1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
  2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.
- J. Test moisture content of concrete to be coated:
  1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
    - a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
  2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
  3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
    - a. Waterproof surfaces exposed to soil or water where specified in Section 07110 - Dampproofing.
  4. Comply with specified minimum moisture content and CSM's written recommendations for moisture vapor transmission rates or relative humidity values.
- K. Masonry surfaces:
  1. Cure for at least 28 days before coating.
  2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
  3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
  4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
  5. Confirm that masonry surfaces are dry before coating application.
    - a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

### **3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES**

- A. Remove rust, scale, and welding slag and spatter.
  1. Remove and grind smooth all excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.



2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.
- B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
  1. Remove grease and oil in accordance with SSPC-SP 1.
  2. Use solvent as recommended by the CSM.
  3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Contractor shall select blast particle size and gradation to produce the specified surface profile.
  4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no "rust back" occurs before coating material application.
- C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.
- D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
  1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
  2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
  3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
  4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.
- E. Field preparation of shop-primed surfaces:
  1. Smooth welds and prominences with power tools before applying field-applied coatings.
  2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
  3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
    - a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
  4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
  5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).
- F. Damaged shop primer or rust bleeding:
  1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
  2. Reject galvanized steel with rust bleeding.



- G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

### **3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE**

- A. Galvanized steel and non-ferrous metal surfaces:
1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
  2. Abrasive blast clean in accordance with SSPC-SP 16.
    - a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
  3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
  4. Test surface for contaminants using copper sulfate solution.
- B. Stainless-steel surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.
- C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.
- D. Sherardized, aluminum, copper, and bronze surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16.
  2. Prepare in accordance with CSM's instructions.
- E. Cadmium-plated, zinc-plated, or sherardized fasteners:
1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.
- F. PVC and FRP surfaces:
1. Lightly sand surfaces to be coated.
    - a. Sand to remove gloss and establish uniform surface profile.
  2. Vacuum to remove loose dust, dirt, and other materials.
  3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

### **3.09 APPLICATION REQUIREMENTS**

- A. Apply coatings in accordance with manufacturer's instructions.
- B. Empty aboveground piping to be coated of contents when applying coatings.
- C. Mechanical equipment shop primed by the manufacturer.
1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
    - a. Contractor shall provide CTR shop coating reports.
  2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
    - a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
  3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.





- D. Verify surface preparation immediately before applying coating in accordance with SSPC SP COM and the SSPC visual standard for the specified surface preparation method.
- E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.
- F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.
- G. Do not apply coatings to a surface until it has been prepared as specified.
- H. Use equipment designed to apply materials specified.
  - 1. Use compressors with moisture traps and filters that remove water and oils from the air.
    - a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
  - 2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.
- I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
  - 1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.
- J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
  - 1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
  - 2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
  - 3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.
- K. Spray application:
  - 1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
  - 2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
  - 3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
  - 4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.
- L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.
- M. Remove all dust on coatings between coats.





- N. Shop and field coats:
1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
    - a. Provide data sheets identifying the shop primer to on-site coating application personnel.
    - b. Perform adhesion tests on the shop primer.
    - c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
    - d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
  2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
    - a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
  3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
    - a. Prime coat adheres to the substrate.
    - b. Coatings adhere to the prime and intermediate coats.
      - 1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
      - 2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.
- O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.
- P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
  2. Before starting application:
    - a. Verify gauges are working properly.
    - b. Complete ratio checks.
    - c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
    - d. Label and retain all spray samples. Submit to Engineer when requested.
- Q. Drying and recoating:
1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
  2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM's printed instructions, before recoating.
  3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time.
    - a. Do not allow excessive drying time or exposure, which may impair bond between coats.
    - b. Recoat all coatings within time limits recommended by CSM.
    - c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
  4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.



5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
  6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
  7. Leave no holidays. Repair all holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
  8. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.
  9. For submerged service or highly corrosive headspace service, provide a letter to the Engineer stating that the lining system is fully cured and ready to be placed into service.
- R. Workmanship:
1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
  2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
  3. Remove splatter and droppings after coating work is completed.
  4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
  5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
  6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
    - a. Brush apply stripe coat to ensure proper coverage.
    - b. Do not stripe coat with spray or roller.
  7. Ensure that finish coat, including repairs, has a uniform color and gloss.
- S. Coating properties, mixing, and thinning:
1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
  2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
  3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
  4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
  5. Mix coatings with 2 or more components in accordance with CSM's instructions.
  6. Where necessary to suit conditions of the surface, temperature, weather and method of application, thin the coating per CSM's recommendations.
    - a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
    - b. Thin coatings to only what is necessary to obtain proper application characteristics.
    - c. Use a thinner recommended by the CSM.



- T. Film thickness and continuity:
  - 1. Apply coating to the specified thicknesses.
    - a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
  - 2. Verify WFT of the coating system first coat and after applying each subsequent coat.
  - 3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
  - 4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
    - a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
  - 5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.
- U. Protecting coated surfaces:
  - 1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
  - 2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.
- V. Special requirements:
  - 1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
  - 2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
  - 3. Areas damaged during erection:
    - a. Prepare surface for spot repairs as specified for the coating system.
    - b. Recoat with prime coat before applying subsequent coats.
    - c. Touch up surfaces after installation.
    - d. Clean and dry surfaces to be coated at time of application.
  - 4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
  - 5. Coat aluminum in contact with concrete.

### **3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS**

- A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
  - 1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.
- B. Apply surfacer or filler and let dry before coating application.
  - 1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions.
    - a. Let concrete substrate dry before applying filler/surfacers or coating system materials.



2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures per CSM's instructions.
  3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
    - a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
    - b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
    - c. Provide relatively flat, uniformly even surface before coating application.
  4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes.
    - a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
    - b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.
- C. Concrete substrate temperatures:
1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
    - a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
  2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
    - a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
    - b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.
- D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and drawings, whichever is stricter.
- E. Concrete coating systems application requirements:
1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

### **3.11 COATING SYSTEM SCHEDULE**

- A. Appendix A specifies surfaces to be coated in the field with the coating systems required.

### **3.12 SURFACES NOT REQUIRING COATING**

- A. Stainless steel piping, valves, pipe supports, instrument sunshades.
- B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.
- C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.



- D. Copper and brass pipe, fittings, valves, etc.
- E. Bronze valves, bearings, bushings, and fasteners.
- F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.
- G. Exterior Concrete.
- H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.
- I. Buried Piping that is encased in concrete or cement mortar.

### **3.13 QUALITY CONTROL**

- A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.
- B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
  - 1. Inspect materials upon receipt to ensure that the CSM supplied them.
  - 2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
  - 3. Inspect and record findings for substrate cleanliness.
  - 4. Inspect and record pH of concrete and metal substrates.
  - 5. Inspect and record substrate profile (anchor pattern).
  - 6. Measure and record ambient air and substrate temperature.
  - 7. Measure and record relative humidity.
  - 8. Check for substrate moisture in concrete.
  - 9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
  - 10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
  - 11. Perform adhesion testing.
  - 12. Measure and record the coating system's thickness.
  - 13. Verify proper curing of the coating system in accordance with the CSM's instructions.
  - 14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.
- C. Contractor shall perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
  - 1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
  - 2. Coated concrete.
  - 3. Perform holiday tests after proper application and coating system cure.



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## **CORRECTIVE MEASURES**

- A. Repair pinholes or holidays identified by Holiday Testing as follows:
  - 1. Remove the coating system with a grinder or other suitable power tool.
  - 2. Remove coating system at all pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
  - 3. Concrete voids: chip back to expose entire cavity in all directions.
    - a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool, and strike off. Cure per CSM's recommendations.
  - 4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
  - 5. Vacuum the prepared area to remove all dust, dirt, etc., leaving clean, sound surfaces.
  - 6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
  - 7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
  - 8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast per CSM's instructions, if the maximum recoat time is exceeded.
  - 9. Apply coating at specified dry film thickness.

### **3.15 CLEANUP**

- A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

### **3.16 FINAL INSPECTION**

- A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.
- B. Conduct subsequent final inspection with Engineer to ensure work conforms to contract documents requirements.
- C. Mark any rework required.
  - 1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION



## **SECTION 10400**

### **SIGNAGE**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Plastic and metal signs for building and site use.

##### **1.02 REFERENCES**

- A. National Fire Protection Association (NFPA):
  - 1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.
- B. Occupational Safety and Health Administration (OSHA).

##### **1.03 SUBMITTALS**

- A. Product data:
- B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.
- C. Samples: Include actual materials.
- D. Manufacturer's installation instructions.

##### **1.04 QUALITY ASSURANCE**

- A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.
- B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.
- C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

#### **PART 2 PRODUCTS**

##### **2.01 PLASTIC SIGNAGE SYSTEM**

- A. Manufacturers:
  - 1. One of the following or equal:
    - a. Best Manufacturing Sign Systems, System 900013.
    - b. Andco Industries Corp., equivalent product.





c. Vomar Products, Inc., equivalent product.

- B. Attachment:
  - 1. Vinyl tape, self-adhering.
- C. Lettering:
  - 1. Helvetica medium, 3/4 inches high.
- D. Material for interior use:
  - 1. Plastic 1/8-inch thick raised letters.
- E. Material for exterior use:
  - 1. Fiberglass 1/4 inch thick with high gloss finish, raised letters, blasted from single piece of fiberglass for integral letter and background.
  - 2. No adhesive as mechanical fastening of letters shall be allowed.
- F. Colors:
  - 1. As selected by Engineer from manufacturer's standard colors.
- G. See Schedule A for specific sign size, location, text, pictogram, and quantity.

## **2.02 METAL SAFETY SIGNS**

- A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
  - 1. Seton Name Plate Co., Special Wording.
  - 2. Emedco.
- B. Danger sign colors:
  - 1. Background: White.
  - 2. Heading: White lettering on red oval with white border in black rectangular panel.
  - 3. Message: Black lettering on white.
  - 4. Size: As scheduled.
- C. Caution sign colors:
  - 1. Background: Yellow.
  - 2. Heading: Yellow lettering on black rectangular panel.
  - 3. Message: Black lettering on yellow.
  - 4. Size: As scheduled.
- D. Safety instruction signs:
  - 1. Background: White.
  - 2. Heading: White lettering on green rectangular panel.
  - 3. Message: Black lettering.
  - 4. Size: As scheduled.
- E. Warning sign colors:
  - 1. Background: Orange.
  - 2. Heading: Black lettering on orange diamond in black rectangular panel.
  - 3. Message: Black lettering on orange.
  - 4. Size: As scheduled.



- F. Notice information signs:
  - 1. Background: White.
  - 2. Heading: White lettering on blue rectangular panel.
  - 3. Message: Black lettering.
  - 4. Size: As scheduled.
- G. Fasteners: Round head stainless steel bolts or screws.
- H. See Schedule B for specific sign size, location, text, and quantity.

### **2.03 EXTERIOR INFORMATION SIGNS**

- A. Able to withstand 100 miles per hour wind load without damage:
  - 1. Manufacturers: One of the following or equal:
    - a. Best Manufacturing Sign Systems; equivalent product.
    - b. Andco Industries Corp., equivalent product.
    - c. Vomar Products, Inc., equivalent product.
- B. Sign panel: Nominal 3 inches thick, consisting of 1/8-inch thick fiberglass material with integral returns fully encapsulating wood and foam core, 1/8-inch radius edges and corners, size as indicated on the Drawings.
- C. Text: Helvetica medium, size and wording as indicated on the Drawings.
- D. Posts: Nominal 3 inch square extruded aluminum sections with aluminum fillers at top and bottom, mounting hardware, and aluminum baseplates drilled for anchor bolts.
- E. Fasteners: Manufacturer's standard, suitable for application.
- F. Colors: As selected from manufacturer's standard colors.

### **2.04 CAST METAL PLAQUE**

- A. Manufacturers: One of the following or equal:
  - 1. Andco Industries Corp.
  - 2. Southwell Co.
  - 3. ARK-RAMOS Inc.
- B. Material: Cast bronze.
- C. Size: Approximately 28 by 34 inches by minimum 3/16 inches thick; lettering, center panel, and trim raised 1/8 inch.
- D. Lettering: Text as indicated on the Drawings. Verify before fabrication.
- E. Finishes:
  - 1. Lettering, center panel, and trim: Fine satin.
  - 2. Background: Finely pebbled, oxidized to dull black color.
- F. Mounting: Concealed with fasteners.



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## **HAZARD MATERIAL SIGNALS**

- A. Manufacturer: One of the following or equal:
  - 1. Seton Name Plate Co.
  - 2. Emedco.
- B. Hazard material signals: In accordance with NFPA 704; vinyl or 40-mil thick aluminum with baked enamel finish panels, letters, and symbols with pressure sensitive adhesive, sizes as required for viewing distances, letters and symbols in accordance with Schedule C.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Protect adjacent surfaces which may be damaged by installation of signs.
- B. Prepare substrates in accordance with sign manufacturer's instructions.
- C. Remove scale, dirt, grease, and other contaminants from substrates.

### **3.02 INSTALLATION**

- A. Install signs in accordance with sign manufacturer's instructions.
- B. Fasten signs securely in level, plumb, and true to plane positions.
- C. Install signs where indicated on the Drawings or as indicated in the following schedules.

### **3.03 SCHEDULES**

- A. Plastic Signage System Schedule.
- B. Metal Safety Sign Schedule.

END OF SECTION



## SCHEDULE A

### PLASTIC SIGNAGE SYSTEM SCHEDULE

- A. Stair Landings:
1. Location: At each floor landing in stairwells.
  2. Height: 60 inches above floor to center of sign.
  3. Size: 6 inches square.
  4. Colors: As selected by Engineer.
  5. Text: Stair number, access or no access to roof to suit application, and floor level, as follows:
- B. Fire Extinguishers:
1. Location: Adjacent to fire extinguishers.
  2. Height: 60 inches above floor to center of sign.
  3. Size: 6 inches square.
  4. Colors: White letters on OSHA Red background.
  5. Text: FIRE EXTINGUISHER.
- C. Nonpotable Water:
1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
  2. Height: In accordance with Typical Detail.
  3. Size: 10 inches wide by 7 inches high.
  4. Heading: CAUTION
  5. Text: IMPURE WATER  
DO NOT DRINK
- D. FOG Offloading Station:
1. Location: At FOG offloading control panel.
  2. Height: 60 inches above floor to center of sign.
  3. Size: 10 inches wide by 7 inches high.
  4. Heading: ATTENTION
  5. Text: DRIVER MAKE SURE THE VENT ON YOUR TANK IS OPEN BEFORE  
STARTING THE UNLOADING OPERATION. UTILITY IS NOT RESPONSIBLE FOR  
DAMAGE TO YOUR TANK.

END OF SCHEDULE A  
PLASTIC SIGNAGE SYSTEM SCHEDULE



## SCHEDULE B

### METAL SAFETY SIGN SCHEDULE

#### E. NONPOTABLE WATER:

1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
2. Height: In accordance with Typical Detail.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: DO NOT DRINK THIS WATER

#### F. HIGH PRESSURE HOSE VALVES:

1. Location: At designated hose valves.
2. Height: 60 inches above floor to center of sign.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: HIGH PRESSURE

#### G. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:

1. Location: On front and back of equipment that starts automatically by remote control.
2. Height: 60 inches above floor to center of sign.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY BY REMOTE CONTROL

#### H. HIGH VOLTAGE WARNING:

1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
2. Height: 60 inches above floor to center of sign.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: HIGH VOLTAGE  
KEEP OUT

#### I. NO SMOKING INFORMATIONAL SIGNS:

1. Location: On exterior face of wall, adjacent to each entry point (exterior door) to all buildings.
2. Height: 60 inches above floor to center of sign. Where metal safety signs are also located adjacent to entry points, place no smoking signs below these signs.
3. Size: 6 inches square.
4. Heading: None.
5. Wording: None.
6. Pictogram: International "No Smoking" symbol.



- J. NO SMOKING WITHIN 25 FEET OF BUILDING ENTRY:
1. Location: As indicated on the Drawings.
  2. Height: Pole mounted with top of sign at 5 feet above grade.
  3. Size: 14 inches wide by 10 inches high.
  4. Heading: NOTICE
  5. Wording: NO SMOKING WITHIN 25 FEET OF BUILDING.
  6. Pictogram: International "No Smoking" symbol.

END OF SCHEDULE B  
METAL SAFETY SIGN SCHEDULE







## SECTION 13446

### MANUAL ACTUATORS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Valve and gate actuators.
  - 2. Handwheel actuators.
  - 3. Hand-cranked geared actuators.
  - 4. Floor Boxes.
  - 5. Floor stands.
  - 6. Key operated valves.
  - 7. Bench stands.
  - 8. Accessory equipment and floor boxes.

##### 1.02 REFERENCES

- A. Aluminum Association (AA):
  - 1. DAF-45 - Designation System for Aluminum Finishes.
- B. American Water Works Association (AWWA).
- C. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. National Electrical Code (NEC).

##### 1.03 DEFINITIONS

- A. NEMA:
  - 1. Type 4X enclosure in accordance with NEMA 250.
  - 2. Type 7 enclosure in accordance with NEMA 250.

##### 1.04 SUBMITTALS

- A. Shop drawings: Include shop drawings and product data with associated gate or valve as an integrated unit.

##### 1.05 QUALITY ASSURANCE

- A. Provide valve actuators integral with valve or gate, except for valve actuators utilizing T-wrenches or keys, and portable gate actuators intended to operate more than 1 valve.
- B. Provide similar actuators by 1 manufacturer.
- C. Provide gates and hand operating lifts by 1 manufacturer.



- D. Provide hydraulic gate lifts by 1 manufacturer.
- E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

## **1.06 MAINTENANCE**

- A. Extra materials:
  - 1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

## **PART 2 PRODUCTS**

### **2.01 VALVE AND GATE ACTUATORS**

- A. Valve actuators:
  - 1. Motorized actuators, and portable gate actuators are specified in 13447 - Electric Motorized Actuators.
  - 2. Manual actuators:
    - a. Material: Type 316 stainless steel.
    - b. Design: Hand lever.
    - c. Spring release handle: 12-inch.
    - d. Notch plate: 10 position.
    - e. Secure with mounting bolts.
    - f. Locking device so that valve can be locked in any position with a wing nut.
  - 3. Stem and cover:
    - a. For submerged valves, provide extension stem as indicated on the Drawings.
  - 4. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
    - a. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
    - b. Rating: Rated for 10 amps, 120 volts alternating current.
    - c. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.
- B. Stem covers:
  - 1. Aluminum pipe:
    - a. Threaded cap on top.
    - b. Bolted aluminum flange on bottom.
    - c. Slots cut 1- by 12-inch at 18 inches on center in front and back of pipe.
    - d. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
  - 2. Ultraviolet light resistant, clear butyrate plastic or polycarbonate pipe:
    - a. Capped on the upper end.
    - b. Either threaded into the top of the gate operators or held in place by bolt-down aluminum brackets.
    - c. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.



3. Staff gauges:
  - a. Adhesive-backed mylar, suitable for outdoor service.
  - b. Calibrated in hundredths of feet.
  - c. Read the weir crest elevations directly.
  - d. Gauge range: 1.5 feet minimum.
  - e. Indicate the following elevations on each staff gauge:
    - 1) -0.75, -0.50, -0.25, 0.0, 0.25, 0.50, 0.75.
  - f. Supplement with a stem-mounted pointer or indicator that permits direct observation of the weir gate crest elevation.
  - g. Apply staff gauges to each stem cover after installation of the cover and after calibration and testing of the weir gates.
  - h. Set gauges precisely by a survey crew using instruments acceptable to the Engineer.
- C. Stem cover flanges, pipes and caps:
  1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
    - a. A 41 - Clear Anodic Coating.
    - b. C 22 - Medium Matte Finish.
- D. Gate stem covers: Concentric with stem.
- E. Position indicators:
  1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.
  2. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.
- F. Manual or power actuator size:
  1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.
- G. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.
- H. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.
- I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.
- J. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.
- K. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.



- L. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.
- M. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

## **2.02 HANDWHEEL ACTUATORS**

- A. Manufacturers: One of the following or equal:
  - 1. Rodney Hunt Co.
  - 2. Waterman Industries, Inc.
- B. Coating: Handwheel as specified in Section 09960 - High-Performance Coatings.
- C. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.
- D. Bearings above and below finished threaded bronze operating nut: Ball or roller.
- E. Wheel diameter: Minimum 24 inches.
- F. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.
- G. Pull to operate: Maximum 40 pounds pull at most adverse design condition.
- H. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.
- I. Grease fittings: Suitable for lubrication of bearings.

## **2.03 HAND-CRANKED GEARED ACTUATORS**

- A. Type: Single removable crank; fully enclosed.
- B. Mounting: Floor and bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.
- C. Operating nut: When scheduled for portable gate actuators.
- D. Geared lifts: 2-speed with minimum ratio of 4 to 1.
- E. Teeth on gears, spur pinions, bevel gears, and bevel pinions: Cut.
- F. Lift nuts: Cast manganese bronze.
- G. Exterior surfaces on cast-iron lift parts: Smooth.



- H. Bearings above and below flange on lift nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.
- I. Crank rotation indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.
- J. Hand cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
  - 1. Revolving brass sleeves.
  - 2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
  - 3. Cast manganese bronze lift nuts.
  - 4. Cast-iron lift parts with smooth exterior surfaces.
- K. Indicator: Dial position type mounted on gear actuator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

#### **2.04 FLOOR BOXES**

- A. Manufacturers: The following or equal:
  - 1. Waterman Industries, Inc.
- B. Floor boxes: Cast-iron; with:
  - 1. Counter type indicator.
  - 2. Hinged, lockable lid with directional arrow.
  - 3. 2-inch square AWWA operating nut.
  - 4. Packing gland providing drip-tight seal around valve shaft.

#### **2.05 FLOOR STAND**

- A. Manufacturers: One of the following or equal:
  - 1. Rodney Hunt Co.
  - 2. Waterman Industries, Inc.
- B. Floor stand assemblies: Heavy-duty cast-iron, suitable for mounting specified actuator.

#### **2.06 BENCH STANDS**

- A. Manufacturers: One of the following or equal:
  - 1. Rodney Hunt Co.
  - 2. Waterman Industries, Inc.
- B. Bench stands: Handwheel actuators or hand crank, geared actuators conforming to hand-cranked geared actuator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

#### **2.07 ACCESSORY EQUIPMENT**

- A. Wall brackets or haunches: As indicated on the Drawings.



- B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.
- C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.
- D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.
- E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.
- F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.
- G. Fasteners: Type 316 stainless steel.
- H. Anchor bolts: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry except that the material shall be Type 316 stainless steel.
- I. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.
- J. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.
- K. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install floor boxes in concrete floor with lid flush with floor.
- B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.
- C. Attach floor stand to structure with anchor bolts.
- D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.



### 3.02 SCHEDULES

- A. Geared actuators: Provide geared actuators for following valves:
  - 1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
  - 2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
  - 3. Plug valves 6 inches, nominal size, and larger.
- B. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.
- C. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION







## SECTION 13447

### ELECTRIC ACTUATORS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Electric motor-driven actuators for valves and gates except for specialty actuators specified with individual valves.

##### 1.02 REFERENCES

- A. American Water Works Association (AWWA):
  - 1. C504 - Standard for Rubber-Seated Butterfly Valves.
  - 2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.
- B. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

##### 1.03 DEFINITIONS

- A. NEMA:
  - 1. Type 4X enclosure in accordance with NEMA 250.
  - 2. Type 7 enclosure in accordance with NEMA 250.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures and Section 15050 - Common Work Results for Mechanical Equipment.
- B. Provide a complete list/schedule of all actuators being provided with their associated tag names as indicated on the design drawings and/or specifications, service process area and the size of the valve they are actuating.
- C. Product data:
  - 1. Electrical ratings:
    - a. Voltage and number of phases.
    - b. Starting and running current.
    - c. Voltage levels and source for control and status.
  - 2. Description of integral control interface.
  - 3. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
  - 4. Gear ratios for both manual and motorized actuation.
  - 5. Opening and closing directions.
  - 6. Allowable starts per hour.
  - 7. List of all included options and accessories.
  - 8. Full travel times.
  - 9. Gearbox data including gear ratio, and gearbox efficiency.



- D. Shop drawings:
  - 1. Wiring diagrams:
    - a. Include all options and expansion cards furnished with each actuator.
  - 2. Dimensioned drawings of each valve and actuator combination.
  - 3. Dimensioned drawings of each valve gearbox.
  - 4. Electric motor data.
- E. Calculations:
  - 1. Operating torque.
  - 2. Maximum torque calculations for seating and unseating.
  - 3. Maximum operating torque at starting and normal operation.
  - 4. Signed by Professional Engineer.
- F. Provide draft vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data:
  - 1. Include a list of all configurable parameters, and the final values for each.
  - 2. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.
- G. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
    - a. Affidavit in accordance with AWWA C542.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
- H. Project closeout documents:
  - 1. Provide final vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

## **1.05 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Manufacturers for lines 3 inch and smaller:
  - 1. The following or equal:
    - a. Rotork Controls Inc.:
      - 1) ROMpak (Quarter-Turn).
      - 2) CMA Range:
        - a) CMR - Multi-Turn.
        - b) CMQ - Quarter-Turn.
- B. Manufacturers for lines 4 inch and larger:
  - 1. One of following or equal:
    - a. Rotork Controls Inc. IQ3 Range:
      - 1) IQ for multi-turn applications.
      - 2) IQT for quarter-turn applications.



- b. Limitorque Corp.:
  - 1) Accutronix MX for multi-turn applications.
  - 2) Accutronix QX quarter-turn applications.
- c. Auma:
  - 1) SA (multi-turn) with Aumatic AC controls.
  - 2) SQ(quarter-turn) with Aumatic AC controls.

## **2.02 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER**

- A. Actuators for valves 3 inches and smaller:
  - 1. Provide actuators complete and operable with all components and accessories required for operation.
  - 2. Power supply:
    - a. Valve motion independent of power supply phase rotation.
    - b. 220/380/440 VAC 3-phase.
  - 3. Size actuator to move valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
    - a. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
  - 4. For all outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
  - 5. Control inputs:
    - a. Capable of using discrete 120 VAC.
    - b. Controls the valve when local-stop-remote is in REMOTE.
    - c. Material: Type 316 stainless steel.
    - d. Provide the following inputs at the actuator:
      - 1) OPEN.
      - 2) CLOSE.
  - 6. Status outputs:
    - a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
      - 1) FULLY CLOSED.
      - 2) FULLY OPEN.
      - 3) REMOTE.
    - b. All output contacts rated for 5 amps, 120 VAC.
  - 7. Analog input:
    - a. Provide a 4-20 milliamp analog input for analog modulating valves when indicated on the Drawings.
    - b. Modulate valve to maintain position based on analog input value.
    - c. Maximum input impedance 250 ohms.
  - 8. Analog output:
    - a. Provide an isolated 4-20 milliamp analog output when indicated on the Drawings.
  - 9. Materials:
    - a. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.
  - 10. Components:
    - a. Motors:
      - 1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.



- 2) Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
  - a) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
  - b) 60 starts per hour minimum for open/close service.
- b. Enclosures:
  - 1) Actuator housing ratings as indicated in the Motorized Actuator Schedule.
  - 2) Stainless steel external fasteners.
- c. Manual actuation:
  - 1) Hand wheel for manual operation.
- d. Gearing: Self-locking, high-alloy steel gears.

## **2.03 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER**

- A. Provide actuators complete and operable with all components and accessories required for operation.
- B. Power supply:
  1. Voltage and phases as indicated in the Motorized Actuator Schedule.
  2. Valve or gate motion independent of power supply phase rotation.
  3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
  4. The actuators shall incorporate all major components such as the motor, starter, local controls, terminals, etc. housed within a self-contained, sealed enclosure.
- C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
  1. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
  2. Size actuators so that gear boxes are not required where possible.
- D. Control interface:
  1. Configuration:
    - a. Provide a non-intrusive, non-contacting interface for configuring all input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
      - 1) Configurable from a handheld configuring tool or input devices on the actuator.
  2. Local interface, integral to actuator:
    - a. Non-intrusive, non-contacting selector switches:
      - 1) LOCAL-STOP-REMOTE:
        - a) Motor actuator operation is prevented with the switch in STOP.
      - 2) OPEN-CLOSE:
        - a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
        - b) Spring return to center.



- c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
  - b. Local display:
    - 1) Valve fully open and fully closed indicators.
    - 2) Numerical display showing actual valve or gate position in percent of travel.
3. Remote control station - (VCP):
  - a. Provide remote control stations for all actuators located more than 5 feet above finished floor/grade or where indicated on the Drawings or Schedule.
    - 1) NEMA rating as listed in the Valve and Gate Schedule.
      - a) Where the rating is not listed, use NEMA Type 4X enclosures for non-hazardous areas, and explosion-proof (XP) Class I Division 1 for hazardous areas.
      - b) All pilot devices shall 30 millimeters, and pilot lights shall be illuminated by LEDs.
    - 2) LOCAL-STOP-REMOTE selector switch.
    - 3) LOCAL mode control devices:
      - a) Operate valve when LOCAL-STOP-REMOTE integral to actuator is in REMOTE and LOCAL-STOP-REMOTE on remote control station is in LOCAL.
      - b) OPEN-STOP-CLOSE maintained switch or OPEN, STOP, and CLOSE pushbuttons where Maintained operation is indicated in the Valve and Gate Schedule.
      - c) OPEN-CLOSE spring-return switch or OPEN and CLOSE pushbuttons where momentary operation is indicated in the Valve and Gate Schedule.
    - 4) Pilots lights to indicate valve position:
      - a) Fully open.
      - b) Fully closed.
4. Rotork's Remote Hand Station:
  - a. Pole mounted.
  - b. Configuration: Bluetooth configuration tool.
  - c. Power: Via attached actuator (24 VDC output).
  - d. Enclosure:
    - 1) IP68.
  - e. Double sealed.
5. Control inputs:
  - a. Capable of using 120 VAC or 24 VDC inputs.
  - b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
  - c. Isolated inputs capable of operating from external control voltage source or internal power supply:
    - 1) Furnish 120 VAC or 24 VDC control power supplies within the actuator.
  - d. Provide the following inputs:
    - 1) OPEN.
    - 2) CLOSE.
    - 3) STOP.
  - e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).



6. Status outputs:
  - a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
  - b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
    - 1) Fully closed.
    - 2) Fully open.
    - 3) LOCAL-STOP-REMOTE in REMOTE position.
  - c. All output contacts rated for 5 amps, 120 VAC, and 24 VDC.
- E. Features:
  1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
  2. Data logging:
    - a. Store diagnostic data and reference data.
    - b. Time-stamped historical operating data, including number of operations and most recent operations.
    - c. Starting torque, maximum running torque, and end of travel torque.
      - 1) Store reference data (recorded during commissioning) and data from last operation.
  3. Provide display of logged data on the actuator, or provisions to download to a personal computer.
- F. Materials:
  1. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.
- G. Components:
  1. Motors:
  2. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
  3. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
    - a. Design requirements for rubber-seated AWWA butterfly valves:
      - 1) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542.
        - a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
        - b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
    - b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
      - 1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C542.
      - 2) Design for the maximum torque and thrust running load over the full cycle.





- 3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
  4. Capable of being removed and replaced without draining the actuator gear case.
  5. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
  6. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
    - a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
    - b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
  7. Provide the following motor protection features:
    - a. Jammed valve (no valve motion detected through a time delay).
    - b. High motor temperature (sensed by an embedded thermostats).
    - c. High torque.
    - d. Single phasing protection.
- H. Enclosures:
1. Actuator housing ratings as indicated in the Motorized Actuator Schedule.
  2. Stainless steel external fasteners.
  3. Provide o-ring seals for each of the following areas:
    - a. Between the terminal compartment and the internal electrical elements.
    - b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
  4. Provide the following minimum enclosure ratings:
    - a. NEMA Type 4X enclosure for general applications.
    - b. NEMA Type 7 enclosure for Class 1 applications.
- I. Position sensing:
1. Electronic and adjustable using a solid-state encoder wheel.
    - a. Mechanical limit switches and potentiometers are not acceptable.
  2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
  3. Valve range and position switch outputs field adjustable.
- J. Torque sensing:
1. Torque shutdown setting: 40 percent to 100 percent rated torque:
    - a. Adjustable in 1 percent increments.
  2. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
  3. Electrical or electronic torque sensing:
    - a. Extrapolating torque from mechanically measured motor speed is not acceptable due to response time.
  4. Independent of variations in frequency, voltage, or temperature.
  5. The actuator shall store actual operational torque curves for retrieval by plant maintenance staff.



6. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
  7. Provide visible verification of torque switch status without any housing disassembly.
- K. Manual actuators:
1. Hand wheel for manual operation.
    - a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
    - b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
      - 1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
      - 2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
  2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.
- L. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
1. Accurately cut to ensure minimum backlash.
- M. Bearings:
1. Anti-friction bearing with caged balls or rollers throughout.
  2. Sealed-for-life type thrust bearings housed in a separate thrust base.
- N. Drive bushing:
1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
  2. Positioned in a detachable base of the actuator.
- O. Lubrication:
1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
  2. Actuators requiring special or exotic lubricants are not acceptable.

## **2.04 ACCESSORIES**

- A. Software:
1. Furnish PC-based diagnostic and configuration software to display diagnostic data.
  2. Provide software communications to the valve actuator using Bluetooth wireless or IrDA infrared communications.
    - a. Provide all accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.
    - b. Where infrared communications are used, furnish an IrDA to USB adapter with a mounting device to secure the infrared element to the valve actuator IrDA port:
      - 1) Provide with a minimum cable length of 3 feet, capable of being extended with a standard USB extension cable.



- B. Termination module cover:
  - 1. Provide sunshades for all outdoor installations of remote control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

## **2.05 SPARE PARTS AND SPECIAL TOOLS**

- A. As specified in Section 01600 - Product Requirements.
- B. Spare parts:
  - 1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
    - a. Stem nut.
    - b. Worm shaft subassembly.
    - c. Drive sleeve subassembly.
    - d. Complete actuator seal kit.
    - e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
    - f. Encoder.
    - g. Control module.
  - 2. Provide 1 spare motor for each size motor furnished.
- C. Setting tool:
  - 1. If required for setting or configuring the actuator, provide a handheld setting tool. Provide a handheld setting tool capable of non-intrusive calibration and interrogation of the actuator.
    - a. Furnish 1 setting tool for every 10 actuators.
    - b. Capable of communicating with PC-based configuration software, and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator.
    - c. Actuator configurations:
      - 1) Capable of storing up to 10 different configurations.
    - d. Diagnostic data:
      - 1) Capable of storing 4 complete sets of diagnostic data.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.
- B. Position visual indicators so that they are most easily visible.

### **3.02 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning, Section 15958 - Mechanical Equipment Testing, and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Source Testing:



- 1) Proof-of-Design and Performance Test Reports in accordance with AWWA C542.
- b. Manufacturer's Certificate of Installation and Functionality Compliance.
2. Manufacturer's Representative on-site requirements:
  - a. Installation: 2 trips, 2-day minimum each.
  - b. Functional testing: 2 trips, 2-day minimum each.
3. Training:
  - a. Maintenance: 4 hours per session, 2 sessions.
  - b. Operation: 2 hours per session, 2 sessions.
- C. Source testing:
  1. Design and Performance Test Reports in accordance with AWWA C542.
  2. Test each actuator with a simulated load.
    - a. Simulate a typical valve load.
  3. Electrical Instrumentation and Controls:
    - a. Test witnessing: not witnessed.
    - b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.
- D. Functional testing:
  1. Installed actuator:
    - a. Test witnessing: Witnessed.
    - b. Conduct Level 2 General Equipment Performance Tests.
    - c. Conduct Level 2 Vibration Tests.
    - d. Conduct Level 2 Noise Tests.
  2. Electrical Instrumentation and Controls:
    - a. Test witnessing: Witnessed.
    - b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.03 MOTORIZED ACTUATOR SCHEDULE**

- A. Provide all actuators indicated on the Drawings:
  1. Major process actuators are listed in the Intelligent Actuator Schedule in this Section.
  2. The Motorized Actuator Schedule does not include all number and types of actuators required for the Project.
- B. Abbreviations relating to type:
  1. BFV = Butterfly Valve.
  2. BV = Ball Valve.
  3. PV = Plug Valve.
  4. SG = Slide Gate.
  5. TWV = Three Way Valve
- C. Abbreviations relating to actuator type:
  1. O/C = Open and Close Service.
  2. MOD = Modulating Service.
- D. Abbreviations relating to controls:
  1. PA = Profibus PA.
  2. DP = Profibus DP.
  3. DN = DeviceNet.



4. FF = Foundation Fieldbus H1.
5. MB = Modbus RTU (RS-485).
6. NET = Manufacturer's proprietary network.
7. A = Analog (4-20 mA) control, modulating duty.
8. D = Discrete control, modulating duty.
9. D-O/C = Discrete Open/Close.
10. EIP = EtherNet/IP



INTELLIGENT ACTUATOR SCHEDULE										
Item	Reference DWG	Tag Number	Type	Size	Actuator Type	NEMA Rating	Voltage/ Phase/ Hz	Notes	Open Time	Controls
FOG Receiving Facility	20M02	FCV- 211	BV	1 HP	O/C	4X	480/3/60		30 s	EIP, D- O/C
Digester FOG Feed No.1	10M05	FCV- 212	PV	1 HP	O/C	7	480/3/60		30 s	EIP, D- O/C
Digester FOG Feed No.2	10M05	FVC- 213	PV	1 HP	O/C	7	480/3/60		30 s	EIP, D- O/C
Hot Water System	10M05	FCV- 214	TWV	1 HP	MOD	7	480/3/60		30 s	EIP, A



## SECTION 15050

### COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Basic design and performance requirements for building mechanical equipment and process mechanical equipment.

##### 1.02 REFERENCES

- A. American Gear Manufacturer's Association (AGMA) Standards:
  - 1. 6001-E08 - Design and Selection of Components for Enclosed Gear Drives.
- B. American Bearing Manufacturers Association (ABMA) Standards:
  - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
  - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. American Petroleum Institute (API):
  - 1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.
- D. ASTM International (ASTM):
  - 1. A36 - Standard Specification for Carbon Structural Steel.
  - 2. A48 - Standard Specification for Gray Iron Castings.
  - 3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
  - 4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
  - 7. A536 - Standard Specification for Ductile Iron Castings.
  - 8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  - 9. B61 - Standard Specification for Steam or Valve Bronze Castings.
  - 10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
  - 11. B505 - Standard Specification for Copper Alloy Continuous Castings.
  - 12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
  - 13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
  - 14. F594 - Standard Specification for Stainless Steel Nuts.
- E. Hydraulic Institute (HI).
- F. Occupational Safety and Health Administration (OSHA).
- G. Unified Numbering System (UNS).





03

## DEFINITIONS

- A. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.
- B. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.
- C. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.
- D. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.
- E. Rotational speed: Same as rotational frequency.
- F. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.
- G. Critical speed: Same as critical frequency.
- H. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.
- I. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

## 1.04 DESIGN REQUIREMENTS

- A. General:
  - 1. Product requirements as specified in Section 01600 - Product Requirements.
  - 2. Project conditions as specified in Section 01610 - Project Design Criteria.
  - 3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
  - 4. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
  - 5. Vibration considerations:
    - a. Resonant frequency:
      - 1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
      - 2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
    - b. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958 - Mechanical Equipment Testing.
  - 6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.



- B. Power transmission systems:
1. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a service factor of 1.5 or greater in accordance with manufacturer recommendations:
    - a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
    - b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.
- C. Equipment mounting and anchoring:
1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames.
    - a. Utilize continuous welds to seal seams and contact edges between steel members.
    - b. Grind welds smooth.
  2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
  3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
  4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01612 - Seismic Design Criteria, and other loads as required for proper operation of equipment.
    - a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
      - 1) The operating weight and location of the centroid of mass for the equipment.
      - 2) Forces and overturning moments.
      - 3) Shear and tension forces in equipment anchorages, supports, and connections.
      - 4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
  5. Anchorage of equipment to concrete or masonry:
    - a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
    - b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    - c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
      - 1) Adjust bolts to final location and secure the sleeve.
  6. Anchorage of equipment to metal supports:
    - a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
  7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.



05

## SUBMITTALS

- A. As specified in Section 01600 - Product Requirements.
- B. Product data:
  - 1. For each item of equipment:
    - a. Design features.
    - b. Load capacities.
    - c. Efficiency ratings.
    - d. Material designations by UNS alloy number or ASTM Specification and Grade.
    - e. Data needed to verify compliance with the Specifications.
    - f. Catalog data.
    - g. Nameplate data.
    - h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
  - 2. Gear reduction units:
    - a. Engineering information in accordance with applicable AGMA standards.
    - b. Gear mesh frequencies.
- C. Shop drawings:
  - 1. Drawings for equipment:
    - a. Drawings that include cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
  - 2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
  - 3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
  - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
  - 5. Recommended or normal operating parameters such as temperatures and pressures.
  - 6. Alarm and shutdown setpoints for all controls furnished.
- D. Calculations:
  - 1. Structural:
    - a. Substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design requirements specified and seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
  - 2. Mechanical:
    - a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
    - b. Substantiate that operating rotational frequencies meet the requirements of this Section.



- c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
  - 1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
  - 2) Results of analysis including first and second critical frequencies of system components and complete system.
- d. Calculations shall be signed and stamped by a licensed engineer.
- 3. Drinking water:
  - a. If applicable, conform to the requirements of Section 01600 - Product Requirements for materials in contact with drinking water.
- E. Operation and maintenance manuals:
  - 1. As specified in Section 01782 - Operating and Maintenance Data.
  - 2. Equipment with bearings:
    - a. Include manufacturer and model number of every bearing.
    - b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
- F. Commissioning submittals: As specified in Section 01756 - Commissioning.
- G. Project closeout documents: As specified in Section 01770 - Closeout Procedures.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.
- B. Ferrous materials:
  - 1. Steel for members used in fabrication of assemblies: ASTM A36.
  - 2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
  - 3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
  - 4. Galvanized steel sheet: ASTM A653, minimum 0.0635-inch (16-gauge).
  - 5. Expanded metal: ASTM A36, 13-gauge, 1/2-inch flat pattern expanded metal.
  - 6. Stainless steel:
    - a. As specified in Section 05120 - Structural Steel.
    - b. In contact or within 36 inches of water: Type 316 or 316L.
    - c. In sea air environment: Type 316 or 316L.
    - d. Other locations: Type 304 or 304L.
    - e. Source cleaning and passivation as specified in Section 05120 - Structural Steel.
- C. Non-ferrous materials:
  - 1. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833, C89520, or C92200 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.



2. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, C89520, C92200, or C93700 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
  3. Aluminum: As specified in Section 05140 - Structural Aluminum.
- D. Dielectric materials for separation of dissimilar metals:
1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.
- E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03600 - Grouting.

## **2.02 ANCHORS AND FASTENERS**

- A. Mechanical anchoring to concrete and masonry:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
    - a. Type 316 stainless steel.
  2. Design as specified in Section 01612 - Seismic Design Criteria.
- B. High-strength fasteners:
1. As specified in Section 05120 - Structural Steel.
- C. Flange bolts:
1. As specified in Section 15052 - Common Work Results for General Piping.
- D. Mechanical assembly fasteners:
1. Stainless steel:
    - a. High-temperature service or high-pressure service:
      - 1) Bolts: ASTM A193, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
      - 2) Nuts: ASTM A194, Grade 8, heavy hex.
      - 3) Washers: Alloy group matching bolts and nuts.
    - b. Low-temperature service:
      - 1) Bolts: ASTM A320, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
      - 2) Nuts: ASTM A194, Grade 8 (Type 304) or Grade B8M (Type 316), heavy hex.
      - 3) Washers: Alloy group matching bolts and nuts.
    - c. General service:
      - 1) Bolts: ASTM F593, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
      - 2) Nuts: ASTM F594, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
      - 3) Washers: Alloy group matching bolts and nuts.



## 2.03 SHAFT COUPLINGS

- A. General:
  - 1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
  - 2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.
- B. Shaft couplings for close-coupled electric-motor-driven equipment:
  - 1. Use for:
    - a. Equipment 1/2 horsepower or larger.
    - b. Reversing equipment.
    - c. Equipment subject to sudden torque reversals or shock loading:
    - d. Examples:
      - 1) Reciprocating pumps, blowers, and compressors.
      - 2) Conveyor belts.
  - 2. Manufacturers: One of the following or equal:
    - a. Lovejoy.
    - b. T.B. Woods.
  - 3. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
  - 4. Manufacture flexible component of coupling from synthetic rubber or urethane.
  - 5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
  - 6. Do not allow metal-to-metal contact between driver and driven equipment.
- C. Shaft couplings for direct-connected electric-motor-driven equipment:
  - 1. Use for 1/2 horsepower or larger and subject to normal torque, non-reversing applications.
  - 2. Manufacturers: One of the following or equal:
    - a. Rexnord.
    - b. T.B. Woods.
  - 3. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
  - 4. Provide flexible connecting element of rubber and reinforcement fibers.
  - 5. Provide service factor of 2.0.
  - 6. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.
- D. Spacer couplings: Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.
- E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer:
  - 1. Includes any engine-driven equipment.

## 2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

- A. General:
  - 1. Unless otherwise noted in the equipment section, provide cartridge-type, double mechanical shaft seals for pumps.
  - 2. Provide a stuffing box large enough for a double mechanical seal.



3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
  4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
  5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
  6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
  7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
    - a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
    - b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
    - c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
    - d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water).
    - e. Double seal applications: Plan 54 (External seal water).
- B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
1. Wastewater, water, and sludge applications:
    - a. Asbestos free.
    - b. PTFE (Teflon) free.
    - c. Braided graphite.
    - d. Manufacturers: One of the following or equal:
      - 1) Chesterton, 1400.
      - 2) John Crane, equivalent product.
  2. Drinking water service:
    - a. Asbestos free.
    - b. Material: Braided PTFE (Teflon).
    - c. Manufacturers: One of the following or equal:
      - 1) Chesterton, 1725.
      - 2) John Crane, equivalent product.
- C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
1. Provide seal types meeting the following requirements:
    - a. Balanced hydraulically.
    - b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
    - c. O-ring: Viton 747.
    - d. Gland: Type 316L stainless steel.
    - e. Set screws: Type 316L stainless steel.
    - f. Faces: Reaction bonded, silicon carbide.
    - g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.





2. Cartridge-type single mechanical:
  - a. Manufacturers: One of the following or equal:
    - 1) Chesterton, S10.
    - 2) John Crane, 5610 Series.
3. Cartridge-type double mechanical: Manufacturers:
  - a. One of the following or equal:
    - 1) Chesterton, S20.
    - 2) John Crane, 5620 Series.
4. Split-face single mechanical: Manufacturers:
  - a. One of the following or equal:
    - 1) Chesterton, 442.
    - 2) John Crane, 3740.
5. Cartridge-type flushless mechanical:
  - a. Manufacturers: One of the following or equal:
    - 1) Chesterton, 156.
    - 2) John Crane, 5870.

## **2.05 GEAR REDUCTION UNITS**

- A. Type: Helical or herringbone, unless otherwise specified.
- B. Design:
  1. Made of alloys treated for hardness and for severe service.
  2. AGMA Class II service:
    - a. Use more severe service condition when such is recommended by unit's manufacturer.
  3. Cast-iron housing with gears running in oil.
  4. Anti-friction bearings.
  5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.
  6. Manufactured in accordance with applicable AGMA standards.
- C. Planetary gear units are not to be used.

## **2.06 BELT DRIVES**

- A. Sheaves:
  1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
  2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
  3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
  4. Key bushings to drive shaft.
- B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
  1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
    - a. Where 2 or more belts are involved, furnish matched sets.
    - b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
    - c. Package in boxes labeled with identification of contents.



- C. Manufacturers: One of the following or equal:
  - 1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
  - 2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

## **2.07 BEARINGS**

- A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
- B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
  - 1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610 - Project Design Criteria.
  - 2. Provide an external oil cooler when required to satisfy the specified operating conditions:
    - a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
    - b. Equip oil cooler with a filler pipe and external level gauge.
- C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
  - 1. Lubrication lines and fittings:
    - a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
    - b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
    - c. Use standard hydraulic-type grease supply fittings:
      - 1) Manufacturers: One of the following or equal:
        - a) Alemite.
        - b) Zerk.
- D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

## **2.08 MOTORS**

- A. As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.

## **2.09 GEAR MOTORS**

- A. Motors as specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.
- B. Helical gearing for parallel shaft drives and worm gearing for right-angle drives.
- C. Manufactures: One of the following or equal:
  - 1. Baldor Electric Company.
  - 2. Bodine Electric Company.



## **2.10 VENDOR CONTROL PANELS**

- A. As specified in Section 17710 – Control Systems: Panels, Enclosures, and Panel Components.

## **2.11 EQUIPMENT SUPPORT FRAMES**

- A. Bolt holes shall not exceed bolt diameter by more than 25 percent, up to a limiting maximum diameter oversize of 1/4-inch.

## **2.12 PIPING AND VALVES**

- A. Piping as specified in Section 15052 - Common Work Results for General Piping.
- B. Valves as specified in Section 15110 - Common Work Results for Valves.

## **2.13 SAFETY EQUIPMENT**

- A. Safety guards:
  - 1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
  - 2. Requirements:
    - a. Allow visual inspection of moving parts without removal.
    - b. Allow access to lubrication fittings.
    - c. Prevent entrance of rain or dripping water for outdoor locations.
    - d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
  - 3. Materials:
    - a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
    - b. Fasteners: Type 304 stainless steel.
- B. Insulation:
  - 1. Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level.
  - 2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.
  - 3. Insulation Type 3 and cover Type 5 as specified in Section 15082 - Piping Insulation.
- C. Warning signs:
  - 1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
  - 2. Material, sign size, and text: As specified in Section 10400 - Signage.
  - 3. Mount warning signs with stainless steel fasteners at equipment.

## **2.14 SPRING VIBRATION ISOLATORS**

- A. Design requirements:
  - 1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.



2. Use steel coil springs.
  3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
- B. Performance requirements: Minimum spring deflection of 1-inch under static load and capable of limiting transmissibility to 10 percent maximum at design operating load.
- C. Manufacturers: One of the following or equal:
1. California Dynamics Corporation, Type RJSD.
  2. Mason Industries, equivalent product.
- D. Materials:
1. Fabricate isolators using welded-steel or shatterproof ductile iron in accordance with ASTM A536 Grade CS-45-12.
  2. Spring steel: ASTM A125.

## **2.15 NAMEPLATES**

- A. Fastened to equipment at factory in an accessible and visible location.
- B. Stainless steel sheet engraved or stamped with text, holes drilled or punched for fasteners.
- C. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.
- D. Text:
1. Manufacturer's name, equipment model number and serial number, motor horsepower when appropriate, and identification tag number.
  2. Indicate the following additional information as applicable:
    - a. Maximum and normal rotating speed.
    - b. Service class per applicable standards.
  3. Include for pumps:
    - a. Rated total dynamic head in feet of fluid.
    - b. Rated flow in gallons per minute.
    - c. Impeller, gear, screw, diaphragm, or piston size.
  4. Include for gear reduction units:
    - a. AGMA class of service.
    - b. Service factor.
    - c. Input and output speeds.

## **2.16 SHOP FINISHES**

- A. Provide appropriate factory coatings as specified in Section 09960 - High-Performance Coatings.
1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

## **2.17 SPECIAL TOOLS**

- A. Supply 1 set of special tools as specified in Section 01600 - Product Requirements.



## **2.18 SOURCE TESTING**

- A. Testing requirements unless specified otherwise in the individual equipment specifications:
  - 1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 15958 - Mechanical Equipment Testing.
  - 2. Motors: As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.
  - 3. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

## **2.19 SHIPPING**

- A. As specified in Section 01600 - Product Requirements.
- B. Prior to shipment of equipment:
  - 1. Bearings (and similar items):
    - a. Pack separately or provide other protection during transport.
    - b. Greased and lubricated.
  - 2. Gear boxes:
    - a. Oil filled or sprayed with rust preventive protective coating.
  - 3. Fasteners:
    - a. Inspect for proper torques and tightness.

## **PART 3 EXECUTION**

### **3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION**

- A. As specified in Section 01600 - Product Requirements.
- B. Inspect fasteners for proper torques and tightness.
- C. Storage:
  - 1. Bearings:
    - a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
  - 2. Gear boxes:
    - a. Inspect to verify integrity of protection from rust.
- D. Protection:
  - 1. Equipment Log shall include description of rotation performed as part of maintenance activities.

### **3.02 INSTALLATION**

- A. Field measurements:
  - 1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
  - 2. Ensure equipment and ancillary appurtenances fit within available space.



- B. Sequencing and scheduling:
  - 1. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place.
  - 2. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
- C. Metal work embedded in concrete:
  - 1. Accurately place and hold in correct position while concrete is being placed.
  - 2. Clean surface of metal in contact with concrete immediately before concrete is placed.
- D. Concrete surfaces designated to receive non-shrink grout:
  - 1. Heavy sandblast concrete surface in contact with non-shrink grout.
  - 2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
  - 3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.
- E. Install equipment in accordance with manufacturer's installation instructions and recommendations.
- F. Lubrication lines and fittings:
  - 1. Support and protect lines from source to point of use.
  - 2. Fittings:
    - a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
    - b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
    - c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.
- G. Alignment of drivers and equipment:
  - 1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
  - 2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
    - a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
    - b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
  - 3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.



4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
  5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
    - a. Allow minimum 48 hours for grout to harden.
    - b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
    - c. Correct alignment as required.
  6. After functional testing is complete, dowel motor or drivers and driven equipment:
    - a. Comply with manufacturer's instructions.
- H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03600 - Grouting.
    - a. Non-shrink epoxy grout required only when indicated on the Drawings.
  2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
  3. Install grout only after:
    - a. Equipment is leveled and in proper alignment.
    - b. Piping connections are complete and in alignment with no strain transmitted to equipment.
  4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
  5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
    - a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
    - b. Use suitable number and size of jack screws.
    - c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
    - d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
    - e. Place and cure grout as specified in Section 03600 - Grouting.
    - f. After grout is cured, remove jack screws and material used to prevent bonding to grout.
      - 1) Provide jack screws to Owner for future use.
    - g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
    - h. Fill holes where jack screws have been removed with grout.
    - i. Cure as specified in Section 03600 - Grouting.
  6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
    - a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
    - b. Place and cure grout as specified in Section 03600 - Grouting.
    - c. Remove wedges or shims.
    - d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
    - e. Fill voids where wedges and shims have been removed with grout.





- f. Cure as specified in Section 03600 - Grouting.
  - 7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
    - a. Metal in contact with grout: Grit blast to white metal finish.
    - b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint, and other material that will reduce bond.
  - 8. Preparation of concrete equipment foundation for grouting:
    - a. Rough concrete surfaces in contact with grout.
    - b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
    - c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
    - d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.
  - 9. Forms and header boxes:
    - a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
    - b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
    - c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
  - 10. Grout placement requirements:
    - a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising:
      - 1) Conform to grout manufacturer's temperature requirements.
    - b. Pour grout using header box.
    - c. Keep level of grout in header box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment.
    - d. Grout shall flow continuously from header box to other side of forms without trapping air or forming voids.
    - e. Vibrate, rod, or chain grout to facilitate grout flow, consolidate grout, and remove entrapped air.
    - f. After grout sets, remove forms and trim grout at 45-degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
    - g. Cure as specified in Section 03600 - Grouting.
  - I. Field welding:
    - 1. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
    - 2. Shielded arc welding.
  - J. Field finishes:
    - 1. Protect motors.
    - 2. Clean equipment.
    - 3. Apply primer and coating systems as specified in Section 09960 - High-Performance Coatings requirements.
  - K. Special techniques:
    - 1. Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.



- L. Tolerances:
  - 1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.
- M. Warning signs:
  - 1. Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

### **3.03 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
  - 1. Mechanical equipment: Level 1 tests as specified in Section 15958 - Mechanical Equipment Testing.
  - 2. Motors: As specified in Sections 16222 - Low Voltage Motors Up to 500 Horsepower and 16950 - Field Electrical Acceptance Tests.
  - 3. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION





## SECTION 15052

### COMMON WORK RESULTS FOR GENERAL PIPING - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Basic materials and methods for metallic and plastic piping systems.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
  - 2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.
- B. American Water Work Association (AWWA):
  - 1. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.
- C. ASTM International (ASTM):
  - 1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 2. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 3. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
  - 4. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  - 5. F37 - Standard Test Methods for Sealability of Gasket Materials.
  - 6. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
- D. NSF International (NSF).

##### 1.03 DEFINITIONS

- A. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
- B. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
- C. Underground pipes: Buried pipes - see A. above.
- D. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
- E. Wet wall: A wall with water on at least 1 side.



## **ART 2 PRODUCTS**

### **2.01 GENERAL**

- A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

### **2.02 ESCUTCHEONS**

- A. Material: Chrome-plated steel plate.
- B. Manufacturers: One of the following or equal:
  - 1. Dearborn Brass Co., Model Number 5358.
  - 2. Keeney Manufacturing Co., Model Number 102 or Number 105.

### **2.03 LINK TYPE SEALS**

- A. Characteristics:
  - 1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
  - 2. Links to form a continuous rubber belt around the pipe.
  - 3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
  - 4. Hardware to be Type 316 stainless steel.
    - a. Provide anti-galling lubricant for threads.
- B. One of the following or equal:
  - 1. Link-Seal.
  - 2. Pipe Linx.

### **2.04 FLANGE BOLTS AND NUTS**

- A. General:
  - 1. Washer:
    - a. Provide a washer for each nut.
    - b. Washer shall be of the same material as the nut.
  - 2. Nuts: Heavy hex-head.
  - 3. Cut and finish flange bolts to project a maximum of 1/4-inch beyond outside face of nut after assembly.
  - 4. Tap holes for cap screws or stud bolts when used.
  - 5. Lubricant for stainless steel bolts and nuts:
    - a. Chloride-free.
    - b. Manufacturers: One of the following or equal:
      - 1) Huskey FG-1800 Anti-Seize.
      - 2) Weicon Anti-Seize High-Tech.
- B. For ductile iron pipe:
  - 1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
    - a. Bolts: ASTM A307, Grade B.
    - b. Nuts: ASTM A563, Grade A.
    - c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.



2. On exposed pipes with pressures greater than 150 psig:
    - a. Bolts: ASTM A193, Grade B.
    - b. Nuts: ASTM A194, Grade 2H.
    - c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
  3. On underwater pipes and pipes adjacent to wet walls:
    - a. Bolts: ASTM A193, Grade B8M.
    - b. Nuts: ASTM A194, Grade 8M.
- C. Plastic pipe:
1. On exposed pipes:
    - a. Bolts: ASTM A307, Grade B.
    - b. Nuts: ASTM A563, Grade A.
    - c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
  2. On underwater pipes and pipes adjacent to wet walls:
    - a. Bolts: ASTM A193, Grade B8M.
    - b. Nuts: ASTM A194, Grade 8M.
- D. Steel pipe:
1. On exposed pipes:
    - a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
      - 1) Bolts: ASTM A307, Grade B.
      - 2) Nuts: ASTM A563, Grade A.
      - 3) Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
    - b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
      - 1) Bolts: ASTM A193, Grade B7.
      - 2) Nuts: ASTM A194, Grade 2H.
  2. On underwater pipes and pipes adjacent to wet walls:
    - a. Bolts: ASTM A193, Grade B8M.
    - b. Nuts: ASTM A194, Grade 8M.

## 2.05 GASKETS

- A. General.
1. Gaskets shall be suitable for the specific fluids, pressure, and temperature conditions.
  2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.
- B. Gaskets for flanged joints in ductile iron for fats, oils, and grease service:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and continuous contact with fats, oils, and grease service.
  2. Gasket material:
    - a. Buna-N with minimum Shore A hardness value of 60.
    - b. Reinforcement: Cloth or synthetic fiber.
    - c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe
  3. Manufacturers: One of the following or equal:
    - a. Pipe less than 48 inches in diameter:
      - 1) Garlock, IFG Style 5500.
      - 2) John Crane, similar product.



- C. Gaskets for flanged joints in ductile iron and steel piping for sewage service:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
  2. Gasket material:
    - a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
    - b. Reinforcement: Cloth or synthetic fiber.
    - c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
  3. Manufacturers: One of the following or equal:
    - a. Pipe less than 48 inches in diameter:
      - 1) Garlock, Style 7797.
      - 2) John Crane, similar product.
    - b. Pipe 48 inches in diameter and larger:
      - 1) Garlock, Style 3760.
      - 2) John Crane, similar product.
- D. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
  2. Material:
    - a. Chemical systems: 0.125-inch thick Viton rubber.
    - b. Sewer and water: 0.125-inch thick SBR.
  3. Manufacturers: One of the following or equal:
    - a. Garlock.
    - b. John Crane, similar product.
- E. Gaskets for flanged joints in gas or liquefied petroleum gas piping:
1. Digester gas in stainless steel, or black steel piping: Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 200 degrees Fahrenheit, and digester gas and mild acid concentrations.
  2. Chlorine gas application in black steel piping: Suitable for pressures equal to or less than 300 pounds per square inch gauge, temperatures equal to or less than 100 degrees Fahrenheit, and chlorine gas application.
  3. Liquefied petroleum, propane, and natural gas applications in black steel piping: Suitable for pressures equal to and less than 250 pounds per square inch gauge, temperatures equal to and less than 100 degrees Fahrenheit, and liquefied petroleum gas, propane gas, and natural gas application.
  4. Material:
    - a. Microcellular Teflon outer layers with rigid center layer.
    - b. Sealability in accordance with ASTM F37, less than 0.55 millimeters per hour leakage of iso-octane at 1,000 pounds per square inch gasket load and 9.8 pounds per square inch fluid pressure.
  5. Manufacturers: One of the following or equal:
    - a. Garlock, Style 3545.
    - b. John Crane, similar product.





- F. Gaskets for flanged joints in low pressure air piping:
  - 1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 300 degrees Fahrenheit, and compressed air service.
  - 2. Material: EPDM elastomer, 1/8-inch thick, 60 Shore hardness, smooth surface.
  - 3. Manufacturers: One of the following or equal:
    - a. Garlock, Style 8314.
    - b. John Crane, similar product.
- G. Gaskets for flanged joints in ductile iron or steel water piping:
  - 1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
  - 2. Material:
    - a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
  - 3. Manufacturers: One of the following or equal:
    - a. Garlock, Bluegard 3300.
    - b. John Crane, similar product.
- H. Gaskets for flanged joints in ductile iron or steel drinking water piping meeting NSF requirements:
  - 1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 200 degrees Fahrenheit.
  - 2. Material:
    - a. EPDM material with 80 Shore A durometer rating.
  - 3. Manufacturers: One of the following or equal:
    - a. Garlock, 98206.
    - b. John Crane, similar product.
- I. Gaskets for grooved joints in ductile iron:
  - 1. Material to be used for following services unless otherwise specified:
    - a. FlushSeal® type or equal
      - 1) For liquid service:
        - a) Nitrile: Grade S; for temperatures to 180 degrees Fahrenheit.
      - 2) For FOG service:
        - a) Buna-N with minimum Shore A hardness value of 60.
      - 3) For hot water service: EPDM.
      - 4) For air service: Fluoroelastomer.
- J. Gaskets for grooved joints in steel piping:
  - 1. Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
    - a. Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
    - b. Gaskets for use with cement-mortar lined steel piping for temperatures less than 180 degrees Fahrenheit shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.



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## REPAIR BANDS

- A. Design requirements:
  - 1. In accordance with AWWA C230.
- B. Materials:
  - 1. Shells: Type 304 stainless steel.
  - 2. Lugs: Removable epoxy coated ductile iron in accordance with ASTM A536.
  - 3. Bolts and nuts: 304 Stainless Steel with fluoropolymer coated nuts.
  - 4. Gaskets: Compounded for water and sewer service.
- C. Manufacturers: One of the following or equal:
  - 1. Romac Industries, Inc.
  - 2. Smith-Blair Inc.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. General:
  - 1. Piping drawings:
    - a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
    - b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
      - 1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
  - 2. Piping alternatives:
    - a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
    - b. Alternative pipe ratings:
      - 1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
      - 2) Piping of different material may not be substituted in lieu of specified piping.
    - c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
    - d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
      - 1) Manufacturer's factory trained representative:
        - a) Provide on-site training for Contractor's field personnel.
        - b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
      - 2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
    - e. Flanged joints: where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.



3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.
- B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
  2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
    - a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
    - b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
    - c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
    - d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
  3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
  4. Core drilled openings:
    - a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
    - b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
    - c. Remove dust and debris from hole using compressed air.
- C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
    - a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
      - 1) Slope plumbing drain piping with a minimum of 1/4-inch per foot downward in the direction of flow.
  2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
  3. Support piping: As specified in Sections 15061 - Pipe Supports, 15062 - Preformed Channel Pipe Support System, and 15063 - Non-Metallic Pipe Support System:
    - a. Do not transfer pipe loads and strain to equipment.
  4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
  5. Assemble piping without distortion or stresses caused by misalignment:
    - a. Match and properly orient flanges, unions, flexible couplings, and other connections.
    - b. Do not subject piping to bending or other undue stresses when fitting piping.



- c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
  - d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
  - e. Alter piping assembly to fit, when proper fit is not obtained.
  - f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.
- D. Buried piping:
  - 1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
  - 2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
    - a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
  - 3. Laying piping:
    - a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
    - b. Place piping with top or bottom markings with markings in proper position.
    - c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
    - d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
    - e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
  - 4. Concrete encase buried pipe installed under concrete slabs or structures.
- E. Venting piping under pressure:
  - 1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
  - 2. Install plug valves as air bleeder cocks at high points in piping.
    - a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
  - 3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
  - 4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09960 - High-Performance Coatings.
- F. Condensate in digester gas piping:
  - 1. Slope digester gas piping to drip traps or low-point drains at minimum 1/2-inch per foot where condensate flows against the gas or 1/4-inch per foot where condensate flows with gas.
  - 2. Install tapered filler pieces between flanges at high points of straight runs to provide for slope reversals.
    - a. Do not subject piping to high stresses in order to change direction.
  - 3. Provide pipe taps, threaded nipples, and 1-inch plug valves at low points in concrete utility boxes with lids.



- G. Restraining buried piping:
  - 1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    - a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
    - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
  - 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
  - 3. Place concrete thrust blocks against undisturbed soil.
  - 4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
  - 5. Provide underground mechanical restraints where specified in the Piping Schedule.
- H. Restraining above ground piping:
  - 1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    - a. When piping is aboveground or underwater, use mechanical or structural restraints.
    - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
  - 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
- I. Connections to existing piping:
  - 1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
    - a. Protect domestic water/potable water supplies from contamination:
      - 1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
      - 2) Provide devices approved by Owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
  - 2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
  - 3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
  - 4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.
- J. Connections to in-service piping:
  - 1. As specified in Section 01140 - Work Restrictions.



- K. Connections between ferrous and nonferrous metals:
  - 1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
  - 2. Nonferrous metals include aluminum, copper, and copper alloys.
- L. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
  - 1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

### **3.02 CLEANING**

- A. Piping cleaning:
  - 1. Upon completion of installation, clean piping interior of foreign matter and debris.
  - 2. Perform special cleaning when required by the Contract Documents.
- B. Cleaning potable water piping:
  - 1. Flush and disinfect potable water piping as specified in Section 01757 - Disinfection.
- C. Cleaning air piping:
  - 1. Perform special cleaning of filtered air piping from the intake clean air plenums to the discharge points and high-pressure air piping.
    - a. Protect surfaces from contamination.
  - 2. Special cleaning shall include wire brushing, power tool cleaning, wiping down with lint-free cloths, brooming, and vacuuming to remove rust, scale, weld spatter, dust, dirt, oil, and other matter deleterious to operation of the air system:
    - a. Do not sandblast installed piping.
  - 3. To the greatest extent possible, clean piping immediately prior to final closure of piping systems:
    - a. Enter piping, clean and wipe down surfaces, and vacuum out residue.
    - b. Clean surfaces not accessible to this cleaning operation after installation within 6 hours preceding installation.
  - 4. Subsequent to cleaning, protect surfaces from contamination by dust, dirt, construction debris, and moisture, including atmospheric moisture:
    - a. Whether or not pipe upstream has been cleaned, temporarily seal openings in partially completed work except when installation is actively in progress.
    - b. When installation is actively in progress, seal openings at the end of each day's construction or when construction is temporarily stopped.
  - 5. Suspend cleaning and seal openings when inclement weather, including dust storms, is imminent.
  - 6. Use clean, dry air for testing the piping and other elements of the system.
  - 7. Prior to introduction of air to the system, blow piping clean.
    - a. Blow with maximum discharge rate possible for minimum 4 hours, using new blowers or compressors and filters.
  - 8. Clean surfaces that become contaminated prior to acceptance.
- D. Conduct pressure and leak test, as specified.



### 3.03 PIPING SCHEDULE





PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>DR</b>	<b>Drain</b>										
	Underground	2-12	PVC	SCH 80	15249 - Polyvinyl Chloride (PVC) Pipe	SW	15 feet/GR	None	None		
	Aboveground	0.5-6	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL or SW	15 feet/GR	None	WBA		
<b>DG</b>	<b>Digester Gas</b>										
	Aboveground (Inside)	3-6	SST	SCH 10S	15286 - Stainless Steel Pipe	WLD or FL, FL where shown	15 psig/LH	None	None		
	Aboveground (Outside)	3-12	SST	SCH 10S	15286 - Stainless Steel Pipe	WLD or FL, FL where shown	15 psig/LH	None	None		Insulate per Specification Section 15082
<b>DS</b>	<b>Digested Sludge</b>										
	Aboveground	10-20	DIP	CL 53	15211 - Ductile Iron Pipe: AWWA C151	FL or GE	100 psig/HH	P401	EPP		



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>FOG</b>	<b>Fats, Oils, Grease</b>										
	Underground	4-6	DIP	250	15211 – Ductile Iron Pipe: AWWA C151	Mech. Rest. MJ	200 psig /HH	GL	2 Layers PEE	180 deg. F	
	Aboveground	4-6	DIP	CL 53	15211 – Ductile Iron Pipe: AWWA C151	GE	100 psig /HH	GL	EPP	180 deg. F	Insulate per Specification Section 15082 where shown on Drawings
<b>HWR</b>	<b>Hot Water Return</b>										
	Underground	4	DIP	250	15211 – Ductile Iron Pipe: AWWA C151	B&SP	45 psig/HH	None	2 Layers of PEE		
	Aboveground	4	DIP	CL 53	15211 – Ductile Iron Pipe: AWWA C151	FL or GE	45 psig/HH	None	EPP		Insulate per Specification Section 15082



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>HWS</b>	<b>Hot Water Supply</b>										
	Underground	4	DIP	250	15211 – Ductile Iron Pipe: AWWA C151	B&SP	45 psig/HH	None	2 Layers PEE		
	Aboveground	4	DIP	CL 53	15211 – Ductile Iron Pipe: AWWA C151	FL or GE	45 psig/HH	None	EPP		Insulate per Specification Section 15082
<b>LP</b>	<b>Liquid Propane</b>										
	Underground	0.5-2	BSP	SCH 40	15270 – Steel Pipe: ASTM A53 - Plant	SCRD or FL	SC	None	PTW		
	Aboveground	0.5-2	BSP	SCH 40	15270 – Steel Pipe: ASTM A53 - Plant	SCRD or FL	SC	None	EPP		Insulate per Specification Section 15082
<b>OF</b>	<b>Overflow</b>	4-10	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL	25 psig/AM	None	WBA		



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>NPW</b>	<b>Non-Potable Water</b>										
	Underground	1-3	PVC	SCH 80	15249 - Polyvinyl Chloride (PVC) Pipe	SW	125 psig /HH	None	None		
		4-10	DIP	150	15211 - Ductile Iron Pipe: AWWA C151	Mech Rest. MJ	125 psig/HH	CM	2 layers PEE		
	Aboveground	0.5-3	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL or SW	125 psig/HH	None	WBA		
<b>V</b>	<b>Vent</b>	6	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL or SW	25 psig/AM	None	WBA		



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>Abbreviations:</b> 1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 15956 - Piping Systems Testing. AM Air method GR Gravity method HH High head method LH Low head method SC Special case 2. Abbreviations to designate piping include the following: B&SP Bell and spigot BSP Black Steel Pipe CI Cast iron CISP Cast iron soil pipe CL Class, followed by the designation CM Cement mortar CTP Coal tar pitch DIP Ductile iron piping EPP Epoxy polyurethane coating FL Flange GA Gauge, preceded by the designation						GE Grooved end joint GL Glass lined GSP Galvanized steel pipe MJ Mechanical joint NPS Nominal pipe size, followed by the number in inches psi pounds per square inch psig pounds per square inch gauge PE Polyethylene PEE Polyethylene encasement PTW Polyethylene tape wrap PVC Polyvinyl Chloride SCH Schedule, followed by the designation SCRD Screwed-On SST Stainless steel SW Solvent welded VCP Vitrified clay piping WBA Waterborne acrylic WLD Weld					

END OF SECTION



## **SECTION 15061**

### **PIPE SUPPORTS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

##### **1.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  - 3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- B. Manufacturer's Standardization Society (MSS):
  - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures
- B. Product data.
  - 1. Design features.
  - 2. Load capacities.
  - 3. Material designations by UNS alloy number or ASTM Specification and Grade.
  - 4. Data needed to verify compliance with the Specifications.
  - 5. Catalog data.
  - 6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

##### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

#### **PART 2 PRODUCTS**

##### **2.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements.



## 2.02 MATERIALS

- A. General:
  - 1. Hot dip galvanized:
    - a. Fabricate as specified in Section 05120 - Structural Steel.
    - b. Hot dip after fabrication of support in accordance with ASTM A123.
    - c. Repair galvanized surface as specified in Section 05120 - Structural Steel.
  - 2. Stainless steel.
    - a. Fabricate as specified in Section 05120 - Structural Steel.
    - b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
    - c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or A967.
      - 1) Passivation treatments using citric acid are not allowed.
    - d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.
- B. Outdoor areas: Areas exposed to the natural outdoor environment:
  - 1. Coated steel, as specified in Section 09960 Hot Dip Galvanized.
- C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
  - 1. Coated steel, as specified in Section 09960.
- D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
  - 1. Type 316L Stainless Steel.
- E. Stainless steel piping system:
  - 1. Type 304 Stainless Steel.
- F. Chemical containment areas and chemical piping:
  - 1. Type 316L Stainless Steel.
- G. Fasteners:
  - 1. As specified in Section 05120 - Structural Steel.

## 2.03 PIPE SUPPORTS

- A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
  - 1. Manufacturers: One of following or equal:
    - a. For stainless steel piping:
      - 1) Bergen-Power, Figure 133.
      - 2) Nibco-Tolco, Figure 103.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 140.
      - 2) Bergen-Power, Figure 133.
      - 3) Cooper B-Line Systems, Inc., Figure B3205.





- B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Bergen-Power, Figure 94.
      - 2) FM Stainless Fasteners.
    - b. For steel and ductile iron piping:
      - 1) Anvil International, Figure 146.
      - 2) Bergen-Power, Figure 94.
- C. Eye bolts:
  - 1. For stainless steel piping:
    - a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
  - 2. For all other piping, unless indicated on the Drawings:
    - a. Welded and rated equal to full load capacity of rod.
- D. Welded eyebolt rod:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 101.
      - 2) FM Stainless Fasteners.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 278.
      - 2) Bergen-Power, Figure 93.
      - 3) Cooper B-Line Systems, Inc., Figure B3210.
- E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 1C.I.
      - 2) Bergen-Power, Figure 100SS.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 97.
      - 2) Cooper B-Line Systems, Inc., Figure B3172.
- F. Adjustable clevis hangers: MSS SP-58, Type 1:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
      - 2) FM Stainless Fasteners, Figure 60.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 260 or Figure 590.
      - 2) Bergen-Power, Figure 100.
      - 3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
- G. Adjustable clevis hangers for insulated pipe: Oversize:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 1A.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 300.



- 2) Bergen-Power, Figure 100EL.
  - 3) Cooper B-Line Systems, Inc. Figure B3108.
- H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 324.
      - 2) Cooper B-Line Systems, Inc., Figure B3110.
      - 3) FM Fasteners, Figure 81.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 181.
      - 2) Cooper B-Line Systems, Inc., Figure B3110.
- I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) FM Stainless Fasteners, Figure 71.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 171.
      - 2) Cooper B-Line Systems, Inc., Figure B3114.
- J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 30M.
      - 2) Cooper B-Line Systems, Inc., Figure B3066.
      - 3) FM Stainless Fasteners, Figure 98.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 195.
      - 2) Cooper B-Line Systems, Inc., Figure B3066.
- K. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
1. Manufacturers: One of following or equal:
    - a. Anvil International, Figure 199.
    - b. Cooper B-Line Systems, Inc., Figure B3067.
- L. Standard U-bolt: MSS SP-58, Type 24:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 110.
      - 2) Cooper B-Line Systems, Inc., Figure B3188.
      - 3) FM Stainless Fasteners, Figure 37.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 137.
      - 2) Bergen-Power, Figure 283.
      - 3) Cooper B-Line Systems, Inc., Figure B3188.
- M. Riser clamps: MSS SP-58, Type 8:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Cooper B-Line Systems, Inc., Figure B3373.



- 2) FM Stainless Fasteners, Figure 61.
  - b. For all other piping, unless indicated on the Drawings:
    - 1) Anvil International, Figure 261.
    - 2) Bergen-Power, Figure 126.
    - 3) Cooper B-Line Systems, Inc., Figure B3373.
- N. Pipe clamps: MSS SP-58, Type 4:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 4.
      - 2) Cooper B-Line Systems, Inc., Figure 3140.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 212.
      - 2) Bergen-Power, Figure 175.
      - 3) Cooper B-Line Systems, Inc., Figure B3140.
- O. Adjustable offset pipe clamp:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 4.
      - 2) Cooper B-Line Systems, Inc., Figure B3149.
      - 3) FM Stainless Fasteners, Figure 63.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 100.
      - 2) Cooper B-Line Systems, Inc., Figure B3149.
- P. Offset pipe clamp:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 8.
      - 2) Cooper B-Line Systems, Inc., Figure 3148.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 103.
      - 2) Cooper B-Line Systems, Inc., Figure B3148.
- Q. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 318.
      - 2) FM Stainless Fasteners, Figure 59.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 259.
      - 2) Bergen-Power, Figure 125.
      - 3) Cooper B-Line Systems, Inc., Figure B3090.
    - c. Threaded pipe stand support stanchion. Match pipe support material.
      - 1) Anvil International, Figure 63T.
      - 2) Bergen-Power, Figure 138.
      - 3) Cooper B-Line Systems Inc., Figure B3088ST.



- R. Spring hangers:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Bergen-Power, Figure 920.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure B-268, Type G.
      - 2) Bergen-Power, Figure 920.
- S. One hole pipe clamps:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping: Engineer knows of no product.
    - b. For all other piping:
      - 1) Anvil International, Figure 126.
      - 2) Carpenter & Paterson, Figure 237S.
- T. Welded beam attachment: MSS SP-58, Type 22:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 304.
      - 2) Cooper B-Line Systems, Inc., Figure 3083.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 66.
      - 2) Bergen-Power, Figure 113A or 113B.
      - 3) Cooper B-Line Systems, Inc., Figure B3083.
- U. Heavy pipe clamp: MSS SP-58, Type 4:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 4H.
    - b. For all other piping, unless called out otherwise on the drawings:
      - 1) Anvil International, Figure 216.
      - 2) Bergen-Power, Figure 298.
- V. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 426.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 257, Type 3.
      - 2) Cooper B-Line Systems, Inc., Figure B3893.
- W. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 - Structural Steel.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.



- B. Field verify support location, orientation, and configuration to eliminate interference prior to fabrication of supports.
- C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.
- D. Use flush shells only where indicated on the Drawings.
- E. Do not use anchors relying on deformation of lead alloy.
- F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1-inch to concrete, masonry, or wood.
- G. Suspend pipe hangers from hanger rods and secure with double nuts.
- H. Install continuously threaded hanger rods only where indicated on the Drawings.
- I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.
- J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.
- K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
  - 1. For stainless steel piping, use stainless steel U-bolts.
  - 2. For all other piping, use galvanized U-bolts.
- L. Support spacing:
  - 1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
  - 2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
  - 3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
  - 4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
  - 5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.
- M. Install supports at:
  - 1. Any change in direction.
  - 2. Both sides of flexible pipe connections.
  - 3. Base of risers.
  - 4. Floor penetrations.
  - 5. Connections to pumps, blowers, and other equipment.
  - 6. Valves and appurtenances.
- N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.
- O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.



- P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.
- Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.
- R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.
- S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.
- T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.
- U. Where pipe is insulated, install over-sized supports and hangers.
- V. Install insulation shield in accordance with MSS SP-58, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the Drawings.
- W. Install riser clamps at floor penetrations and where indicated on the Drawings.
- X. Coat support system components as specified in Section 09960 - High-Performance Coatings.

END OF SECTION



## SECTION 15063

### NON-METALLIC PIPE SUPPORT SYSTEM

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Non-metallic pipe support system including the following:
  - 1. Channel framing, and components.
  - 2. Pipe clamps.
  - 3. Fittings.
  - 4. Fasteners.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. E84 - Test Method for Surface Burning Characteristics of Building Materials.

##### 1.03 SYSTEM DESCRIPTION

- A. Design responsibility:
  - 1. The manufacturer of the non-metallic pipe support system shall be considered the designer of the support system.
  - 2. Prepare design calculations utilizing the design criteria included in these Specifications.
  - 3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.
- B. Design requirements:
  - 1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
  - 2. Maximum allowable deflection: 1/240 of span.
  - 3. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
  - 4. Future loads:
    - a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
    - b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
    - c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
  - 5. Seismic design criteria: As specified in Section 01612 - Seismic Design Criteria as specified for mechanical equipment.
  - 6. Spacing of supports: As required to comply with design requirements but not more than 5 feet.





## **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings.
- C. Calculations.

## **1.05 QUALITY ASSURANCE**

- A. Supply materials from a single manufacturer with sole responsibility for the pipe support system.
- B. The supplied system, including pipe clamps, shall be interchangeable with industry standard 1-5/8-inch steel and fiberglass channel framing systems.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Transportation, handling, storage, and installation shall be in accordance with the manufacturers printed instructions.

# **PART 2 PRODUCTS**

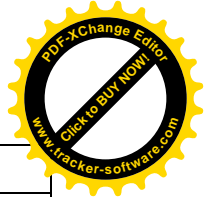
## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. StrutTech.
  - 2. Unistrut.

## **2.02 MATERIALS**

- A. Fiberglass resin: Corrosion-resistant premium grade vinylester.
- B. Injection molded components: Polyurethane thermoplastics.
- C. Flame spread of fiberglass:
  - 1. Vinylester fiberglass (Series VF): Class 1, ASTM E84.
  - 2. Polyurethane: V-O UL 94V.
- D. Physical properties of fiberglass:

	<b>Longitudinal</b>	<b>Transverse</b>
Tensile Strength	37,500 pounds per square inch, (psi)	10,000 pounds per square inch, (psi)
Tensile Modules	3.0 X 10 <sup>6</sup> psi	1.0 X 10 <sup>6</sup> psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0 X 10 <sup>6</sup> psi	1.0 X 10 <sup>6</sup> psi
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi



	Longitudinal	Transverse
Izod Impact	30 foot-pounds per square inch	5 foot-pounds per square inch

- E. Surface veil: Fiberglass channel shall have polyester surface veil over 100 percent of the surface to provide protection against degradation from ultraviolet light.
- F. Touch-up resin:
  - 1. Manufacturers: The following or equal:
    - a. Krylon, 7006-Satin Polyurethane Clear Finish.

## 2.03 COMPONENTS

- A. Channel framing:
  - 1. All channel framing shall be supplied with integral notches 1-inch on center.
  - 2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.
- B. Pipe clamps:
  - 1. Adjustable type: Non-metallic and non-conductive.
  - 2. Fixed type:
    - a. Pipe clamps for pipe less than 6 inches in diameter shall be non-metallic and non-conductive.
    - b. Pipe clamps for pipe equal to and greater than 6 inches in diameter shall be fiberglass.
- C. Channel fittings:
  - 1. Make fittings and post bases from glass-filled polyurethane or polyester.
- D. Fasteners:
  - 1. Make fasteners from one of the following materials:
    - a. Glass-filled polyurethane.
    - b. Vinylester fiberglass.
- E. Cushion strip:
  - 1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets this criteria.
    - a. Manufacturers: One of the following or equal:
      - 1) Anvil, AS 3795.
      - 2) Unistrut, P2600 Unicushion.



## **ART 3     EXECUTION**

### **3.01    INSTALLATION**

#### **A.    General:**

1.    Install in accordance with manufacturer's instructions, shop drawings, and as indicated on the Drawings.
2.    Seal machined edges and holes with touch-up resin.

**END OF SECTION**



## SECTION 15075

### EQUIPMENT IDENTIFICATION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Equipment nameplates.
  - 2. Special items.

##### 1.02 SUBMITTAL

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings:
  - 1. Product data.
  - 2. Installation instructions.
- C. Samples.

##### 1.03 QUALITY ASSURANCE

- A. Regulatory requirements: Comply with Arkansas Department of Environmental Quality (ADEQ) Arkansas Pollution Control and Ecology Commission (AP&EC) Regulation 6.

#### PART 2 PRODUCTS

##### 2.01 EQUIPMENT NAMEPLATES

- A. Material and fabrication:
  - 1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.
- B. Fasteners:
  - 1. Number 4 or larger oval head stainless steel screws or drive pins.
- C. Text:
  - 1. Manufacturer's name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

##### 2.02 SPECIAL ITEMS

- A. In addition, special coating of following items will be required:



Item	Color
Valve handwheels and levers	Red
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

- B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify satisfactory conditions of substrate for applying identification.
- B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

### **3.02 PREPARATION**

- A. Prepare and coat surfaces of special items as specified in Section 09960 - High-Performance Coatings.
- B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION



## SECTION 15076

### PIPE IDENTIFICATION - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Pipe identification including the following:
  - 1. Pipe identification by color and legend.
  - 2. Underground warning tape.
  - 3. Tracer wire.
  - 4. Witness markers.
  - 5. Valve identification.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. A13.1 - Scheme for the Identification of Piping Systems.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Submit following:
  - 1. Product data.
  - 2. Samples.
  - 3. Manufacturer's installation instructions.
  - 4. Submit following as specified in Section 01770 - Closeout Procedures:
    - a. Operation and Maintenance Data.
    - b. Warranty.

#### PART 2 PRODUCTS

##### 2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

- A. Manufacturers:
  - 1. One of the following or equal:
    - a. Seton, Opti Code Pipe Markers.
    - b. Lab Safety Supply.
    - c. Marking Services, Inc.
- B. Materials:
  - 1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
    - a. Lettering:



Nominal Pipe Diameter	Lettering Size
Less than 1.5 inches	1/2-inch
1.5 inches to 2 inches	3/4-inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

b. Marker colors:

Service	Lettering	Background
Flammables, chemicals, toxics	Black	Yellow
Water, nontoxic solutions or low hazard liquids	White	Green
Nonflammable or nontoxic gases	White	Blue
Fire quenching fluids (foam, fire water, CO <sub>2</sub> Halon)	White	Red

2. Coating: As specified in Section 09960 - High-Performance Coatings.
3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4-inch high identifying lettering.
4. Pipe identification tag chains: Aluminum or stainless steel.
5. Snap-on markers: Markers with 3/4-inch high letters for 3/4 to 4-inch pipe or covering, or 5-inch high letters for 5-inch or larger pipe or cover:
  - a. Manufacturers: One of following or equal:
    - 1) Brady BradySnap-On B-915.
    - 2) Seton Setmark.

## 2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:

1. Manufacturer: One of the following or equal:
  - a. Seton Name Plate Co.
  - b. T. Christy Enterprises, Inc.
2. Material:
  - a. Polyethylene tape for prolonged underground use.
  - b. Minimum tape thickness: 4 mils.
  - c. Overall tape width: 6 inches.
  - d. Message: "CAUTION" with the name of the service followed by "LINE BURIED BELOW." in black lettering on colored background in accordance with approved APWA colors.
    - 1) Water: Blue.
    - 2) Sewer: Green.
    - 3) Telephone: Orange.
    - 4) Gas and other services: Yellow.
  - e. Aluminum backing or solid aluminum core.

B. Tracer wire:

1. Manufacturers: One of the following or equal:
  - a. Kris-Tech Wire.





- b. Corpro.
  - 2. Materials: One of the following or equal:
    - a. Solid copper conductor
    - b. Thickness minimum: 10 gauge.
    - c. Insulation:
      - 1) Match insulation color to the color of the pipe being installed.
      - 2) UF type, direct bury.
      - 3) 30 mil HMWPE.
  - 3. Splicing Kit:
    - a. Manufacturers: One of the following or equal:
      - 1) Ryall Electric Co., 3M Kit#82-A1.
  - 4. Station Box:
    - a. Lid and collar materials: Cast iron.
    - b. Able to withstand heavy traffic loading.
    - c. Manufacturers: One of the following or equal:
      - 1) Farwest Corrosion Control Co, Glenn 4 Test Station.
- C. Witness markers:
  - 1. Manufacturers: One of the following or equal:
    - a. Carsonite Composites, Utility Marker.
    - b. Hampton Technical Associates, Inc.
  - 2. Materials:
    - a. Glass fiber and resin reinforced thermosetting composite material.
    - b. UV resistant.
  - 3. Constructed as a single piece.
  - 4. Pointed at the bottom end.
  - 5. Information to be included on the marker:
    - a. "Caution" (type of service) "Pipeline".
    - b. Phone number for Underground Service Alert.
    - c. Phone number for Owner in case of emergency.
    - d. Station number.
    - e. Offset:
      - 1) Only provide offset if marker is not directly over the pipe.
    - f. Name of appurtenance or fitting (e.g. 45, BO, ARV, etc.)

## **2.03 VALVE AND GATE IDENTIFICATION**

- A. Provide valve and gate schedule for each valve and gate in the Work with the following information:
  - 1. Identification number.
  - 2. Location.
  - 3. Type.
  - 4. Function.
  - 5. Normal operating position.
- B. Identification tag requirements.
  - 1. Diameter: 2-inches.
  - 2. Material:
    - a. Buried applications: Stainless steel.
    - b. Buried applications with concrete marker: Brass.
    - c. Above ground and in-chase applications: 19 gauge aluminum or PVC.
  - 3. Stamp tags in 1/4-inch high letter:



4. Provide non-corrosive metal wire suitable for attaching the tag to the operator base.
  5. Secure tags to valve or gate:
    - a. Attach tags in such a way as to allow free and full operation of the valve or gate.
  6. Buried applications with concrete marker: Secure tags to concrete marker.
- C. Submittal requirements:
1. Submit 2 samples of the type of tag proposed and the manufacturer's standard color chart and letter styles to the Engineer for review.
- D. Manufacturer: The following or equal:
1. Seton Name Plate Co.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify satisfactory conditions of substrate for applying identification.
- B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

### **3.02 PREPARATION**

- A. Prepare and coat surfaces as specified in Section 09960 - High-Performance Coatings.
- B. Prepare surface in accordance with product manufacturer's instructions.

### **3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION**

- A. Identify exposed piping, valves, and accessories in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.
- B. Color code:
  1. Paint piping with colors as scheduled in Piping Color Code and Marker Schedule.
- C. Lettering and flow direction arrows:
  1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4-inch high letters on 3/4 through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
  2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.
- D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.



- E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.
- F. Metal tags:
  - 1. Where outside diameter of pipe or pipe covering is 5/8-inch or smaller, provide metal pipe identification tags instead of lettering.
  - 2. Fasten pipe identification tags to pipe with chain.
  - 3. Where tags are used, color code pipe as scheduled.

### **3.04 BURIED PIPING IDENTIFICATION**

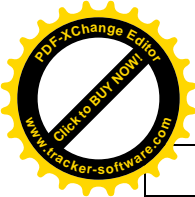
- A. Underground warning tape:
  - 1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.
- B. Tracer wire:
  - 1. Install on all non-metallic pipe.
  - 2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
  - 3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
  - 4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
    - a. Twisting the wires together is not acceptable.
- C. Witness markers:
  - 1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
  - 2. Place markers at appurtenances located in unpaved areas.
  - 3. Embed markers at least 18 inches into the soil.

### **3.05 APPLICATION**

- A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.
- B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15-foot spacing on piping runs.
- C. Provide piping marker letters and colors as scheduled.
- D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

### **3.06 PIPING COLOR CODE AND MARKER SCHEDULE**

<b>Service Fluid</b>	<b>Pipe Color</b>	<b>Marker Legend</b>
Digester Sludge	Dark Brown	DIGESTER SLUDGE
FOG	Dark Brown	FOG



Service Fluid	Pipe Color	Marker Legend
Non-Potable Water	Light Blue	NON-POTABLE WATER
Potable Water	Light Blue	POTABLE WATER
Hot Water Supply	Light Gray	HOT WATER SUPPLY
Hot Water Return	Light Gray	HOT WATER RETURN
Tank Drain	Charcoal	TANK DRAIN
Vent Pipe	Yellow	VENT PIPE
Digester Gas	Red	DIGESTER GAS
Propane	Red	PROPANE

Letters	Color of Pipe	Color of Bands	Color of Letters
Digester Sludge	Dark Brown	None	White
FOG	Dark Brown	None	White
Non-Potable Water	Light Blue	Dark Gray	Black
Potable Water	Light Blue	None	Black
Hot Water Supply	Light Gray	White	Black
Hot Water Return	Light Gray	Black	Black
Tank Drain	Charcoal	None	White
Vent Pipe	Yellow	None	Black
Digester Gas	Red	Yellow	White
Propane	Red	None	White

END OF SECTION



## SECTION 15082

### PIPING INSULATION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Insulation for piping and related systems that are not plumbing systems.

##### 1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
  - 1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
  - 2. C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
  - 3. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
  - 4. C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
  - 5. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
  - 6. C552 - Standard Specification for Cellular Glass Thermal Insulation.
  - 7. C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
  - 8. C929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
  - 9. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
  - 10. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  - 11. D2310 - Standard Classification of Machine-Made "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
  - 12. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
  - 13. E96 - Standard Test Methods for Water Vapor Transmission of Materials.

##### 1.03 DEFINITIONS

- A. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.
- B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.



- C. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.
- D. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E84.
- E. Interior: Piping that is installed inside a building.
- F. K factor: Thermal conductivity determined in accordance with ASTM C177 or C518.
- G. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
- H. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

#### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
  - 1. Insulation properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
  - 2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
  - 3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.
  - 4. Pre-insulated ductile iron piping: In addition to information required for insulation and jacket as specified above and information required as specified in Section 15211 - Ductile Iron Pipe: AWWA C151 for ductile iron piping, include catalog cutsheets, specifications, installation instructions, backfill procedures, and dimensioned drawings for pre-insulated ductile iron piping system.
  - 5. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.
  - 6. Laboratory report: Provide certified laboratory report stating that insulation is not manufactured using chlorinated polymers and does not contain chlorides, bromides, sulfates, or fire-rated materials.
- C. Provide warranty as specified in Section 01783 - Warranties and Bonds.

#### **1.05 REGULATORY REQUIREMENTS**

NOT USED



## PART 2 PRODUCTS

### 2.01 PIPE INSULATION, GENERAL REQUIREMENTS

- A. As specified in Section 01600 - Product Requirements.
- B. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

TABLE 1. Required Insulation Thicknesses

Required Insulation Thicknesses (inches)					
Service Temperature Range as Designated in Insulation Schedule at End of this Section	Nominal Pipe Diameters				
	1 inch and Less	1.25 to 2 inches	2.5 to 4 inches	5 to 10 inches	Over 10 inches
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0

### 2.02 PIPE INSULATION

- A. Insulation types: Provide in accordance with the insulation types listed and scheduled.
- B. Insulation, Type 1:
  - 1. Insulation material: Closed cell elastomeric insulation.
  - 2. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
  - 3. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
  - 4. Fire ratings:
    - a. Flame spread: 25 or less.
    - b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
  - 5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.
  - 6. Manufacturers: One of the following or equal:
    - a. Armacell, AP Armaflex.
    - b. Aeroflex USA Inc., Aerocel® AC.
- C. Insulation, Type 2:
  - 1. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
    - a. In accordance with ASTM C547, Class 1.
    - b. Provide with factory installed vapor barrier.





- 1) Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type I.
- 2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
- 3) Circumferential butt seals: 4-inch wide tape or similar properties or 4-inch wide overlap with adhesive seal.
- 4) Vapor barrier permeability: 0.02 perms or lower.
- 5) Vapor barrier flame spread rating: 25 or less.
2. Minimum temperature range: Minus 0 degrees Fahrenheit to plus 850 degrees Fahrenheit.
3. K factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-inch/hour-square feet degrees Fahrenheit.
4. Maximum moisture absorption, volume percent: 5.
5. Manufacturers: One of the following or equal:
  - a. Owens-Corning , Fiberglas™ FLEXWRAP® ASJ
  - b. Johns Manville, Micro-Lok® HP.
  - c. Knauf Insulation, Earthwool® Redi-Klad® 1000° Pipe Insulation.
- D. Insulation, Type 3:
  1. Insulation material: Rigid cellular glass in accordance with ASTM C552, Type II.
  2. Temperature range: Minus 450 degrees Fahrenheit to plus 900 degrees Fahrenheit.
  3. K factor at 75 degrees Fahrenheit: Not more than 0.32 BTU-inch/hour-square feet-degrees Fahrenheit.
  4. Minimum average density: 7.5 pounds per cubic foot.
  5. Maximum moisture absorption, volume percent: 5.
  6. Minimum compressive strength: 87 pounds per square inch.
  7. Moisture permeability: 0.00 perm-inch.
  8. Manufacturers: One of the following or equal:
    - a. Owens- Corning, Foamglas® One™.
- E. Insulation, Type 4:
  1. Insulation material: Asbestos-free, rigid calcium silicate in accordance with ASTM C533; Type I for process temperatures up to 1,200 degrees Fahrenheit.
  2. K factor at 500 degrees Fahrenheit: 0.55 for Type I.
  3. Maximum average (dry) density: 14.5 pounds per cubic foot.
  4. Compressive strength: 100 pounds per square inch, to produce a 5-percent compression.
  5. Manufacturers: The following or equal: In accordance with ASTM C533 Type I:
    - a. Johns Manville, Thermo-12 Gold.

## 2.03 INSULATION JACKETS

- A. Jacket, Type 1:
  1. Material: 28 ounces per square yard polyvinyl chloride on polyester fabric; total thickness 0.028-inch minimum.
  2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
  3. Color: As selected by the Engineer from manufacturer's standard colors.
  4. Overlap: 1-inch minimum at joints and fittings.
  5. Joint seal: Self-sealing lap tape.



6. Fittings: Factory made with full thickness insulation.
  7. Manufacturers: The following or equal:
    - a. Techlite® Insulation, 379 SSL Series.
- B. Jacket, Type 2:
1. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
  2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
  3. Color: White.
  4. Overlap: 1-inch minimum at joints and fittings.
  5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
  6. Fittings: Factory made with full thickness insulation.
  7. Manufacturers: One of the following or equal:
    - a. Johns Manville, Zeston® 2000 PVC.
    - b. Proto Corp., LoSMOKE PVC.
    - c. Speedline® Corp., Smoke-Safe™ PVC.
- C. Jacket, Type 3:
1. Material: Aluminum, Alloy 5005; 0.016-inch (26-gauge) minimum thickness.
  2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
  3. Bands: 0.5-inch wide, 0.0508-inch (16-gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
  4. Joint seal: Apply waterproof adhesive at joints and overlaps.
  5. Fittings: Custom fit of same materials.
  6. Manufacturers: One of the following or equal:
    - a. Childers Products.
    - b. Premetco International.

## **2.04 VAPOR BARRIERS**

- A. Vapor barrier, Type 1:
1. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
  2. Permeability: 0.02 perms or lower.
  3. Maximum flame spread rating: 25.
  4. Edge seal: Pressure-sensitive tape lap seal.
  5. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
- B. Vapor barrier, Type 2:
1. Material: Mastic.
  2. Manufacturers: One of the following or equal:
    - a. Benjamin Foster, No. 30-76.
    - b. Insul-Coustic, No. I.C.-580.
    - c. Foster Products, 36-10/46-10 Weatherite.
    - d. Childers Products CP10/11 Vi-Acrl.



## 2.05 RELATED MATERIALS

- A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard-duty adhesives are not permitted.

## 2.06 REMOVABLE INSULATING BLANKETS

- A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.
- B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3 inches in nominal size and larger. Insulate equipment and piping appurtenances less than 3 inches with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.
- C. Manufacturers: One of the following, or equal:
  - 1. Thermal Energy Products, Inc., Energy Wrap.
  - 2. Accessible Products, Thermazip 2000 Jacket.
  - 3. Owens Corning, Temp-Mat.
- D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
  - 1. Use: For service temperatures up to 800 degrees Fahrenheit.
  - 2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees Fahrenheit.
  - 3. Cover: 17-ounce fabric with both sides covered with silicone-impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
  - 4. Cover fasteners: Use one of the following systems:
    - a. Grommets in the blanket and stainless steel wire.
    - b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.
- E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit:
  - 1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit.
  - 2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
  - 3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
  - 4. Cover fasteners: Use one of the following systems:
    - a. Grommets in the blanket and stainless steel wire.
    - b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

## 2.07 SHIPPING

- A. As specified in Section 01600 - Product Requirements.



## PART 3 EXECUTION

### 3.01 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01600 - Product Requirements.
- B. Store insulation materials and accessories under cover and protected from moisture.
- C. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

### 3.02 PREPARATION

- A. Pressure test piping and complete application of coating system before applying insulation.
- B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.
- C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

### 3.03 INSULATION SCHEDULE

TABLE 2. Insulation Schedule

Service Designation <sup>(1)</sup>	Location <sup>(2)</sup>	Insulation Type <sup>(3)</sup>	Jacket Type <sup>(2,3)</sup>	Service Temp. °F <sup>(4)</sup>	Vapor Barrier
Digester Gas (DG)	Exterior	3	3	60 – 120	Type 2
Hot Water Supply (HWS)	Exterior	3	3	100-200	Type 2
Hot Water Return (HWR)	Exterior	3	3	100-200	Type 2
Hot Water Supply (HWS)	Interior	2	3	100-200	Type 2
Hot Water Return (HWR)	Interior	2	3	100-200	Type 2
Fats, Oils, Grease (FOG)	Exterior	3	3	Below 180	Type 2
Fats, Oils, Grease (FOG)	Interior	2	3	Below 180	Type 2
Non-Potable Water	Exterior	2	3	Below 70	Type 1

Notes:

- 1. Refer to Piping Schedule in Section 15052 - Common Work Results for General Piping for service designations.
- 2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
- 3. Contractor may select from options listed.
- 4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by TABLE 1. Required Insulation Thicknesses.
- 5. Insulate all piping systems that are specified to be heat traced.



### 3.04 INSTALLATION

- A. Install insulation and jacket materials in accordance with manufacturer's written instructions.
- B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.
- C. Butt longitudinal and circumferential insulation joints firmly together.
- D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.
- E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.
- F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.
- G. Fittings:
  - 1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
  - 2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
  - 3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.
- H. Valves:
  - 1. Insulate valves 3 inches in nominal size and larger with removable insulating blankets.
  - 2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.
- I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.
- J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.
- K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.
- L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.
- M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.



- N. Thermally isolate all insulation closure locations (end caps, transitions, etc.) Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.
- O. Apply piping identification on jackets as specified in Section 15076 - Pipe Identification.

END OF SECTION







## SECTION 15110

### COMMON WORK RESULTS FOR VALVES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Basic requirements for valves.

##### 1.02 REFERENCES

- A. American Water Works Association (AWWA):
  - 1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.
- B. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
  - 2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
  - 3. A536 - Standard Specification for Ductile Iron Castings.
- C. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.
- D. Society for Protective Coatings (SSPC):
  - 1. SP7 - Brush-Off Blast Cleaning.
  - 2. SP10 - Near-White Blast Cleaning.

##### 1.03 DESIGN REQUIREMENTS

- A. Pressure rating:
  - 1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
  - 2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.
- B. Valve to piping connections:
  - 1. Valves 3 inches nominal size and larger: Flanged ends.
  - 2. Valves less than 3 inches nominal size: Screwed ends.
  - 3. Plastic valves in plastic piping:
    - a. Up to 2.5 inches: Provide solvent or heat welded unions.
    - b. 3 inches and above: Provide solvent or heat-welded flanges.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.



- B. Product data:
1. Submit the following information for each valve:
    - a. Valve type, size, pressure rating, Cv factor.
    - b. Coatings.
    - c. Power valve actuators:
      - 1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
      - 2) Complete wiring diagrams and control system schematics.
    - d. Manual valve actuators:
      - 1) Information on valve actuator including size, manufacturer, model number.
    - e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
    - f. Certifications of reference standard compliance:
      - 1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
    - g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
    - h. Factory test data.
- C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.
1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.
- D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
- E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

## **1.05 QUALITY ASSURANCE**

- A. Manufacturer qualifications:
1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

## **1.06 DELIVERY STORAGE AND HANDLING**

- A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

# **PART 2 PRODUCTS**

## **2.01 MATERIALS**

- A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.



- B. Valve and operator bolts and nuts:
  - 1. Fabricated of stainless steel for the following installation conditions:
    - a. Submerged in sewage or water.
    - b. In an enclosed space above sewage or water.
    - c. In structures containing sewage or water, below top of walls.
    - d. At openings in concrete or metal decks.
  - 2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
  - 3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.
- C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.
- D. Valve bodies: Cast iron in accordance with ASTM A126, Class 30 minimum or ductile iron in accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

## **2.02 INTERIOR PROTECTIVE LINING**

- A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.
- B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.
- C. Lining types:
  - 1. Fusion bonded epoxy:
    - a. Manufacturers: The following or equal:
      - 1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
    - b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
    - c. Apply in accordance with manufacturer's published instructions.
    - d. Lining thickness: 0.010 to 0.012-inch, except that:
      - 1) Lining thickness in grooves for gaskets: 0.005-inch.
      - 2) Do not coat seat grooves in valves with bonded seat.
    - e. Quality control:
      - 1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
      - 2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
      - 3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
      - 4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
      - 5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.



2. High solids epoxy:
  - a. Product equivalent to high solids epoxy specified in Section 09960 - High-Performance Coatings.
    - 1) Certified in accordance with NSF 61 for drinking water use.
    - 2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy coating specified in Section 09960 - High-Performance Coatings.
  - b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
  - c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
    - 1) Repair holidays and other irregularities and retest coating.
    - 2) Repeat procedure until holidays and other irregularities are corrected.

## **2.03 UNDERGROUND VALVES**

- A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.
- B. Coating and wrapping:
  1. Prior to installation, coat buried valves with 2 coats of protective coal tar as specified in Section 09960 - High-Performance Coatings.
  2. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15211 - Ductile Iron Pipe: AWWA C151.
    - a. Ascertain that polyethylene wrapping does not affect operation of valve.

## **2.04 STEAM VALVES**

- A. Valves in steam or steam condensate piping: Ductile iron body in accordance with ASTM A536, Grade 65-45-12 minimum or cast steel or forged steel.

## **2.05 VALVE BOXES**

- A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.
- B. Do not support boxes on valve, valve operator, or pipe.
- C. Boxes:
  1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
  2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.
- D. Manufacturers: One of the following or equal:
  1. Tyler Pipe Industries, Inc.
  2. Neenah Foundry Co.



## **2.06 VALVE OPERATORS**

- A. Valve operator "Open" direction: Open counterclockwise.
- B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels.
- C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
  - 1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
  - 2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.
- D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
  - 1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
  - 2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.
- E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Preparation prior to installation:
  - 1. Install valves after the required submittal on installation has been accepted.
  - 2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.
- B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

### **3.02 INSTALLATION**

- A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.
- B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
  - 1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.



2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.
- C. Install valves with their stems in vertical position above the pipe, except as follows:
  1. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
  2. Install buried plug valves with geared operators with their stems in a horizontal position.
- D. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.
- E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.
- F. Valves with threaded connections:
  1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
  2. Apply pipe joint compound or Teflon tape on external (male) threads to prevent forcing compound into valve seat area.
- G. Valves with flanged connections:
  1. Align flanges and gasket carefully before tightening flange bolts.
  2. When flanges are aligned, install bolts and hand tighten.
  3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.
- H. Valves with soldered connections:
  1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
  2. Position valves in full open position before starting soldering procedure.
  3. Apply heat to piping rather than to valve body.

### **3.03 FIELD APPLIED COATING OF VALVE EXTERIOR**

- A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
  1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
  2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.



### **3.04 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services from each manufacturer for all valves supplied:
  - 1. Provide Manufacturer's Certificate of Source Testing.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
- C. As specified elsewhere for specific valve types, sizes or actuators.
  - 1. Source testing.
  - 2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION







## SECTION 15114

### CHECK VALVES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Check valves.
- B. As specified in Section 15110 - Common Work Results for Valves.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Inch Standard.
- B. American Water Works Association (AWWA):
  - 1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.
- C. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
  - 2. A313 - Standard Specification for Stainless Steel Spring Wire.
  - 3. A536 - Standard Specification for Ductile Iron Castings.
  - 4. B582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
  - 5. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

##### 1.03 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Check valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
    - a. In either horizontal or vertical position.
    - b. Suitable for service working pressures up to 150 pounds per square inch gauge.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15110 - Common Work Results for Valves.



- C. Commissioning submittals:
1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

## **1.05 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 SWING CHECK VALVES**

- A. Valves 1/4-inch through 3 inches:
1. Manufacturers: One of the following or equal:
    - a. Crane Valve Co., Number 36.
    - b. Lunkenheimer Co., Figure 554Y.
  2. Valve design:
    - a. Threaded joints.
    - b. Y-pattern body with integral seat.
    - c. Hinged disc.
    - d. Access to valve seat for regrinding without disassembly of piping.
  3. Materials:
    - a. Body, cap, hinge, and disc: Bronze.
- B. Valves 4 inches through 24 inches:
1. Manufacturers: One of the following or equal:
    - a. Kennedy, Figure 106LW or M&H, Model 159.
    - b. Mueller Co., Model A-2600.
    - c. APCO Model 250.
    - d. Crispin SWL Series.
  2. Valve design:
    - a. In accordance with AWWA C508.
    - b. Constructed to permit top entry and removal of internal components without removing the valve.
    - c. Equipped with outside lever and weight.
  3. Materials:
    - a. Body:
      - 1) Digester Mixing: Cast iron, ASTM A126 Class B or ASTM A536 Grade 65-45-12 Ductile Iron.
      - 2) FOG service: Stainless steel.
    - b. Disc:
      - 1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze. FOG service to be stainless steel.
      - 2) 4-inch valves: Bronze or stainless steel rings and seats. FOG service to be stainless steel.
      - 3) 6 inches and larger valves: Bronze-faced or stainless steel rings and seats. FOG service to be stainless steel.
      - 4) Seat:
        - a) Fluid: Water
          - (1) EPDM.
        - b) Fluid: FOG
          - (1) Buna N.



- c. Hinge pins: Stainless steel.

## **2.02 DUCKBILL CHECK VALVES**

- A. Manufacturers: One of the following or equal:
  - 1. Tide Flex, Series TF-1.
- B. Design:
  - 1. When line pressure inside the valve exceeds the backpressure outside the valve, the line pressure forces the bill of the valve to open, allowing flow to pass. When backpressure exceeds the line pressure, the bill of the valve is forced closed preventing backflow.
  - 2. Maximum downstream head: 17 feet.
  - 3. Cracking pressure, 1 to 2 inches w.c.
  - 4. Flat bottom, flared top.
- C. End connection:
  - 1. Flanged.
- D. Materials of construction:
  - 1. Single piece elastomer construction with internal polyester fabric reinforcing all vulcanized into a composite material.
    - a. Internal reinforcing sufficient to maintain structural integrity under the specified operating conditions.
    - b. Exterior applications require coating for UV protection and to resist pest gnawing.
  - 2. Elastomeric material: Buna-N.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install valves as specified in Section 15110 and the manufacturer's instructions.

### **3.02 FIELD APPLIED COATING OF VALVE EXTERIOR**

- A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
  - 1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
  - 2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.



03

## COMMISSIONING

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
  - 1. Valves:
    - a. Test witnessing: Witnessed.
    - b. Conduct pressure and leak test, as specified in Section 15956 - Piping Systems Testing.

END OF SECTION



## **SECTION 15116**

### **PLUG VALVES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Non-lubricated plug valves.
  - 2. Lubricated plug valves.
  - 3. Multi-port plug valves.
  - 4. Multi-port plug valves for digester gas service shall be as specified in Section 11381 - Digester Appurtenances.

##### **1.02 REFERENCES**

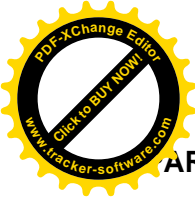
- A. American Water Works Association (AWWA):
  - 1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
  - 2. C606 - Grooved and Shouldered Joints.
- B. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
  - 2. A536 - Standard Specification for Ductile Iron Castings.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures and 15110 - Common Work Results for Valves.
- B. Product data.
- C. Shop drawings.
- D. Calculations.
- E. Vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.
- F. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning:
    - a. Interior coating.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

##### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.



## ART 2 PRODUCTS

### 2.01 GENERAL

- A. As specified in Section 15110 - Common Work Results for Valves.

### 2.02 NON-LUBRICATED PLUG VALVES

- A. Manufacturers: One of the following or equal:
1. DeZurik, "PEC".
  2. Clow Valve.
- B. Design:
1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
  2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
    - a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
    - b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
    - c. Valves in FOG service: Resilient material suitable for abrasive stream and petroleum or digester gas at continuous duty at 180 degrees Fahrenheit. Stream with pH of 2 to 8 standard units.
  3. Compression washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
  4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
  5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
  6. Clearly mark valves to indicate their open and closed positions.
  7. Provide valves with ends as required by piping details indicated on the Drawings.
    - a. Grooved end body valves:
      - 1) Usage: Plug valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints and as indicated on the Drawings.
      - 2) Grooved end joint design: In accordance with AWWA C606.
- C. Materials:
1. Body and plug: ASTM A126, Class B, cast-iron with plug face of Buna N or other manufacturer-recommended material suitable for the intended service as specified under paragraph "Design" above.
  2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8-inch on surfaces contacting the plug face.
  3. Stem bearing and bottom bearing: Type 316 stainless steel
  4. Internal parts, except the body and plug: Type 316 stainless steel
  5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.





## **2.03 LUBRICATED PLUG VALVES**

- A. Manufacturers: One of the following or equal:
  - 1. Nordstrom.
  - 2. Walworth.
- B. Type: Semi-steel tapered plug valves.
- C. Design:
  - 1. Plug removable through top of valve.
  - 2. Combined lubricant screw and grease gun fitting, of the type where the pressure of the grease can be used to raise the plug slightly off its seat.
- D. Where indicated on the Drawings or specified, provide plug valves with high head extension and floor stand with indicator. Provide worm gear-operated valves with worm shaft extension and floor stand, and with indicator supplied by manufacturer of plug valve:
  - 1. Equip floor stands serving plug valves with individual operating wrenches.

## **2.04 VALVE OPERATORS**

- A. Furnish valves with an operating wrench or worm gear operator:
  - 1. Equip valves 4 inch nominal size and smaller with a lever operator.
  - 2. Equip valves 6 inch nominal size and larger with a worm gear operator.

## **2.05 COATING**

- A. Coat and test interior metal surfaces as specified in Section 15110 - Common Work Results for Valves.
- B. Coat exterior metal surfaces as specified in Section 09960 – High Performance Coatings.
- C. Field applied coating of valve exterior:
  - 1. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
    - a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
    - b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

## **2.06 SHIPMENT, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS**

- A. As specified in Section 01600 - Product Requirements.



## **ART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install valves as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.
  - 1. Unless differently indicated on the Drawings install valves as follows:
    - a. For installation in horizontal pipes, install the valve with flow against face of plug. Install the valve laying on its side so plug rotates 90-deg to open. In the open position, the plug is located in the top half of the valve body.
    - b. For installation in vertical pipes, install the valve with seat at the top.
- B. For valves requiring lubrication: Lubricate and fill extended lubricant pipes with lubricant suitable for service intended.

### **3.02 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
  - 1. Valves:
    - a. Test witnessing: Witnessed.
    - b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION



## SECTION 15117

### SPECIALTY VALVES

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Specialty valves.
- B. As specified in Section 15110 - Common Work Results for Valves.

##### **1.02 REFERENCES**

- A. American Society of Civil Engineers (ASCE):
  - 1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.
- B. American Society of Mechanical Engineers (ASME):
  - 1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.
- C. American Water Works Association (AWWA):
  - 1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
  - 2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).
- D. ASTM International (ASTM):
  - 1. A48 - Standard Specification for Gray Iron Castings.
  - 2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
  - 3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
  - 4. A536 - Standard Specification for Ductile Iron Castings.
  - 5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.
  - 6. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
- E. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

##### **1.03 DEFINITIONS**

- A. NEMA Type 4 enclosure in accordance with NEMA 250.

##### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15110 - Common Work Results for Valves.



- C. Commissioning submittals:
  - 1. Backflow preventer certification.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

## **1.05 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 RESERVOIR (ALTITUDE) CONTROL VALVES**

### **2.02 FLOAT VALVES**

- A. Manufacturers: One of the following or equal:
  - 1. Cla-Val Co., Number 124.
  - 2. GA Industries, Figure 5560.
- B. Float valves: Pilot controlled, diaphragm, or piston actuated from hydraulic pressure of liquid flowing through valve.
- C. Design:
  - 1. Valves: Single seated. Open wide when the float is at low level, and close driptight at high level.
  - 2. Float level: Adjustable in the field.

### **2.03 HYDROSTATIC PRESSURE RELIEF VALVES**

- A. Flap gate type:
  - 1. Manufacturers: One of the following or equal:
    - a. Clow Corp.
    - b. Neenah Foundry Co.
  - 2. Design:
    - a. Provide valves with vertical seat design and offset single pivoted hinge.
    - b. Valve components: Flap gate, body with flanged end, hinge pin, and gate seat ring.
    - c. Design valve so that flap gate begins to open at a head of 1/3 the inner diameter of the valve body.
    - d. Cement and mechanically retain gate seat ring in place.
  - 3. Materials:
    - a. Flap gate and body: Cast iron in accordance with ASTM A126 Class B or bronze in accordance with ASTM B584 UNS Number C84400.
    - b. Hinge pin: Bronze of the type specified in the preceding subparagraph or stainless steel in accordance with ASTM A276 Type 304.
    - c. Gate seat ring: EPDM.
- B. Pop-up type:
  - 1. Manufacturers: One of the following or equal:
    - a. Clow Corp.
    - b. Neenah Foundry Co.



2. Design:
  - a. Design valve to begin opening at a maximum head of 9 inches.
  - b. Integrally cast locking lugs into body.
    - 1) Prevent groundwater pressure from separating the cover and strainer from the body.
  - c. The cover and the strainer shall be easily removed by release from the locking lugs.
  - d. Provide bronze seats pressed and sealed into grooves on the top of body and Buna-N seal on the underside of cover.
    - 1) Machine seats to form bronze -to- Buna-N contact when the cover is in closed position.
3. Materials:
  - a. Cover, body, and strainer: Cast-iron in accordance with ASTM A126, Class B.

## **2.04 PUMP CONTROL VALVES**

- A. Manufacturers: One of the following or equal:
  1. Cla-Val Co., Model 60-11.
  2. GA Industries, Inc., Model 1730-D.
- B. Operation:
  1. Opening and closing rates: Adjustable over a minimum range of 30 seconds to 2 minutes.
  2. Suitable at rated working pressure of 250 psi.
  3. Function as a check valve during power failure.
- C. Design:
  1. Pilot valve strainer.
  2. Adjustable pilot valve with stainless steel trim.
  3. Flanged ends.
  4. Valve position indicator.
  5. Solenoid valve: 120 volts alternating current, Class F coil, NEMA Type 4X enclosure.
  6. Limit switch: 120 volts alternating current, NEMA Type 4X enclosure.
- D. Materials:
  1. Valve body: Cast or ductile iron.
  2. Body trim: Bronze.
  3. Diaphragm: EPDM.

## **2.05 SOLENOID VALVES**

- A. 2-way solenoid valves:
  1. Manufacturers: One of the following or equal:
    - a. Automatic Switch Co., Series 8210.
    - b. Skinner Electric Valve Division, Series C.
- B. 3-way solenoid valves:
  1. Manufacturers: One of the following or equal:
    - a. Automatic Switch Co., Series 8320.
    - b. Skinner Electric Valve Division, Type A4.



- C. 4-way solenoid valves:
  - 1. Manufacturers: One of the following or equal:
    - a. Automatic Switch Co., Bulletin 8344.
    - b. Skinner Electric Valve Division, Series V9.
- D. Design:
  - 1. Valves: Suitable for service under the following conditions:
    - a. Fluid: Water.
    - b. Temperature of fluid: 35-180 degrees Fahrenheit.
    - c. Piping test pressure: 150 pounds per square inch gauge.
  - 2. Unless otherwise indicated on the Drawings, provide valves that meet the following requirements:
    - a. Minimum NEMA Type 4 enclosure.
    - b. 120 VAC operation.
    - c. Suitable for use as indicated on the Drawings.
    - d. Minimum Class F coil insulation.
  - 3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
  - 4. Furnish with manual/bypass operators.
- E. Materials:
  - 1. Body: Brass or bronze.
  - 2. Seats: Resilient material.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install as specified in Section 15110 - Common Work Results for Valves in accordance with manufacturer's published instructions.
- B. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.

### **3.02 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
  - 2. Manufacturer's Representative onsite requirements:
    - a. Installation: 1 trip, 1 day minimum.
    - b. Functional Testing: 1 trips, 1 day minimum each.
    - c. Training:
      - 1) Maintenance: 2 hours per session, 2 sessions.
      - 2) Operations: 2 hours per session, 2 sessions.

END OF SECTION



## SECTION 15119

### AIR AND VACUUM RELIEF VALVES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Air release valves, air and vacuum valves, and air vents.
- B. As specified in Section 15110 - Common Work Results for Valves.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  - 2. B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
- B. American Water Works Association (AWWA).
- C. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
  - 2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
  - 3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
  - 4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15110 - Common Work Results for Valves.
- C. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

##### 1.04 WARRANTY

- A. Provide warranty as specified in Section 01783 - Warranties and Bond.





## **ART 2 PRODUCTS**

### **2.01 AIR RELEASE VALVES, WATER SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Valve and Primer Corp., DeZURIK/APCO Series 200.
  - 2. Multiplex Manufacturing Co., Crispin PL Series.
- B. Design:
  - 1. Pressure rating: 150 pounds per square inch gauge.
  - 2. Inlet: Screwed, 2-inch.
  - 3. Orifice size: 1/4-inch diameter.
- C. Materials:
  - 1. Valve body: Cast iron.
  - 2. Float and internal trim: Type 316 stainless steel.
  - 3. Seat or valve plunger: Buna-N.

### **2.02 AUTOMATIC AIR VENTS, HOT WATER SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. ITT-Bell and Gossett, Number 87.
  - 2. Hoffman Specialty Manufacturing Corp., Number 78.

### **2.03 AIR RELEASE VALVES, SEWAGE SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Valve and Primer Corp., DeZURIK/APCO, Series 400.
  - 2. Multiplex Manufacturing Co., Crispin Series S.
- B. Design:
  - 1. Operation: Release accumulated air in sewage pipelines operating under pressure. After entrained air escapes through the orifice, the orifice is plugged by a needle mounted on a compound lever mechanism.
  - 2. Internal components removable through top cover without removing valve from pipeline.
  - 3. Pressure rating: 150 pounds per square inch.
  - 4. Orifice size: 1/4-inch diameter.
  - 5. Connections: Threaded, 2-inch diameter inlet and threaded, 1/2-inch diameter outlet.
- C. Accessories:
  - 1. Inlet shutoff valve. Utilize eccentric plug valve.
  - 2. 2 blowoff valves for backflushing.
  - 3. 10 feet of hose with quick disconnect couplings.
- D. Materials:
  - 1. Body: Cast iron.
  - 2. Float: Type 316 stainless steel.
  - 3. Needle: Buna-N.



## **2.04 AIR AND VACUUM VALVES, SEWAGE SERVICE**

- A. Float activated air and vacuum release valves:
  - 1. Manufacturers: One of the following or equal:
    - a. Multiplex Manufacturing Co., Crispin SA Series.
    - b. Valve and Primer Corp., DeZURIK/APCO, Series 401.
  - 2. Design:
    - a. Operation: Release air from pipeline as pipeline is filled and allow air to enter pipeline as pipeline is drained.
    - b. Internal components removable through top cover without removing valve from pipeline.
    - c. Pressure rating: 150 pounds per square inch.
  - 3. Accessories:
    - a. Inlet shutoff valve. Utilize eccentric plug valve.
    - b. 2 blowoff valves for backflushing.
    - c. 10 feet of hose with quick disconnect couplings.
  - 4. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
  - 5. Materials:
    - a. Body: Cast iron.
    - b. Float: Type 316 stainless steel.
    - c. Seat: Buna-N.

## **2.05 COMBINATION AIR VALVES - SEWAGE SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Valve and Primer Corp., DeZURIK/APCO, Series 440.
  - 2. Multiplex Manufacturing Co., Crispin Series US.
- B. Design:
  - 1. Operation: Automatic exhaust and intake of large quantities of air during filling and draining of pipelines, respectively, and release of accumulated air while pipeline is under pressure.
  - 2. Design: Utilize compound lever system in conjunction with large and small orifices.
  - 3. Internal parts removable through top cover without removing valve from pipeline.
  - 4. Pressure rating: 150 pounds per square inch.
  - 5. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
  - 6. Accessories:
    - a. Inlet shutoff valve.
    - b. 2 blowoff valves for backflushing.
    - c. 10 feet of hose with quick disconnect couplings.
- C. Materials:
  - 1. Body: Cast iron.
  - 2. Float: Type 316 stainless steel.
  - 3. Needle: Buna-N.



## **ART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install as specified in Section 15110 - Common Work Results for Valves and manufacturer's instructions.
- B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

### **3.02 FIELD APPLIED COATING OF VALVE EXTERIOR**

- A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coating.
  - 1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the manufacturer.
  - 2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, remove existing coating by abrasive blast cleaning and apply the coating system used for coating adjacent piping in accordance with Section 09960 - High-Performance Coating.
    - a. Submerged valves: SP-5 White Metal Blast cleaning.
    - b. Other valves: SP-10 Near-white blast cleaning.

### **3.03 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
  - 1. Valves:
    - a. Test witnessing: Witnessed.
    - b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

**END OF SECTION**



## SECTION 15120

### PIPING SPECIALTIES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Piping specialties including:
  - 1. Flexible rubber connections.
  - 2. Bellows type expansion joints.
  - 3. Vibration control joints.
  - 4. Transition fittings.
  - 5. Pipe saddles.
  - 6. Tapping sleeves.
  - 7. Spray nozzles.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
- B. American Water Works Association (AWWA):
  - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
  - 2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
- C. ASTM International (ASTM):
  - 1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
  - 2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 4. A536 - Standard Specification for Ductile Iron Castings.
- D. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
  - 2. 372 - Drinking Water System Components - Lead Content.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. For each piping product in this Section as applicable:
    - a. Design features.
    - b. Load capacities.
    - c. Material designations by UNS alloy number or ASTM Specification and Grade.
    - d. Data needed to verify compliance with the Specifications.



- e. Catalog data.
  - f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
- C. Calculations:
- 1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.
- D. Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning:
- 1. Provide as specified in this Section.

#### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

### **PART 2 PRODUCTS**

#### **2.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements.
- B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

#### **2.02 FLEXIBLE RUBBER CONNECTIONS**

- A. Manufacturers: One of the following or equal:
  - 1. Mercer Rubber Co., Type 150 Vibraflex.
  - 2. Red Valve Co., Inc., Part Number P-5.
- B. Provide flexible rubber connections with 3/8 inch thick EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.
- C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

#### **2.03 BELLOWS TYPE EXPANSION JOINTS**

- A. Expansion joints for general service:
  - 1. Expansion joints: Flexible bellows type, or as otherwise specified or indicated on the Drawings.
  - 2. Manufacturers:
    - a. Expansion joints: One of the following or equal:
      - 1) Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
      - 2) Flex-Weld, Inc., Keflex, Series 308.
      - 3) Victaulic, Depend-o-Lok, Omniflex stainless bellows expansion joint.
    - b. Pipe alignment guides: One of the following or equal:
      - 1) Senior Flexonics Pathway, Inc.
      - 2) Flex-Weld, Inc.



- c. Intermediate supports: Provide with protective saddles. One of the following or equal:
  - 1) Unistrut Corporation, Roller-type.
  - 2) Bergen-Paterson Pipe Support Corp.
- 3. Design:
  - a. Expansion joint rating: 150 pounds per square inch gauge, at 300 degrees Fahrenheit.
  - b. Bellows: Multi-ply (3 ply minimum) stainless steel, equipped with a self-draining liner guide.
  - c. Axial travel of expansion joints: Not less than 1.50 inches.
  - d. Ends: 150 pound ASME flanges, Victaulic, Depend-o-Lok Airmaster/Fluidmaster coupled ends, or plain suitable for welding connections, as required for piping in which installed.

- B. Expansion joints for steam and hot water:
  - 1. Manufacturers: One of the following or equal:
    - a. Flex-Weld, Inc., Keflex, Series 308-1215.
    - b. Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
    - c. Victaulic, Depend-o-Lok Omniflex Expansion Joint.
  - 2. Design:
    - a. Single reinforced bellows type or Victaulic mechanical couplings.
    - b. Pressure and temperature ratings: 150 pounds per square inch gauge, and 500 degrees Fahrenheit service.
    - c. Bellows: Multi-ply (3 ply minimum) Type 321 stainless steel, equipped with a Type 321 stainless steel liner.
    - d. Axial travel of expansion joints: 3 inches minimum.
    - e. Ends: 150 pound ASME flanges.

## **2.04 SLIP TYPE EXPANSION JOINTS**

- A. Expansion joints for steam cleaned piping:
  - 1. Manufacturers: One of the following or equal:
    - a. Smith-Blair, Inc., Number 612 with slip pipe and without limit rods.
    - b. Dresser Industries, Inc., Style 63, Type 2.
  - 2. Line and coat slip pipe and interior of body with fusion-bonded epoxy of minimum 0.012-inch thickness.
  - 3. Packing: Suitable for temperatures greater than 212 degrees Fahrenheit.
- B. PVC expansion joints:
  - 1. Flexible bellows type.
  - 2. Manufacturers: One of the following or equal:
    - a. NDS Flow Management, Quik-Fix.
    - b. Chemtrol.
  - 3. Materials: PVC with EPDM o-ring.
  - 4. Design:
    - a. 150 pound per square inch pressure rating.
    - b. Double o-ring seal.
    - c. Axial travel: Not less than 1.5 inches.
    - d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.



## **2.05 VIBRATION CONTROL JOINTS**

- A. Manufacturers:
  - 1. Braided bronze flexible vibration joints 2 inches and less in size: One of the following or equal:
    - a. Senior Flexonics Canada, Inc., Type BRC bronze connectors.
    - b. Flex-Weld, Inc., Keflex, Type KFCB.
  - 2. Flexible vibration joints larger than 2 inches: One of the following or equal:
    - a. Senior Flexonics Canada, Inc., Type TCS.
    - b. Flex-Weld, Inc., Keflex, Series 151-TR-1215.
  - 3. Corrugated stainless steel with stainless steel braid flexible vibration joints: One of the following or equal:
    - a. Senior Flexonics Canada, Inc., Type BSFS stainless steel connectors.
    - b. Flex-Weld, Inc., Keflex, Type USFNSS-31.
- B. Design:
  - 1. Flexible vibration joints 2 inches and smaller: Braided bronze, suitable for pressures of not less than 250 pounds per square inch gauge.
  - 2. Flexible vibration joints larger than 2 inches: Flexible bellows type, suitable for pressures of not less than 150 pounds per square inch gauge, at 70 degrees Fahrenheit, except as follows:
    - a. Provide vibration joints in piping subject to test pressures higher than 150 pounds per square inch gauge, suitable for such higher pressures.
    - b. Bellows: Stainless steel, equipped with a stainless steel liner.
    - c. Ends: ASME Class 150 flanges.
  - 3. Vibration joints in high-pressure air piping and in digester gas piping: Corrugated Type 316 stainless steel with stainless steel braid, suitable for pressures of not less than 150 pounds per square inch gauge.
    - a. Ends: ASME Class 150 flanges.
- C. Protection: Protect vibration absorbers against end loading and torsional stresses by anchoring attached piping.

## **2.06 TRANSITION FITTINGS**

- A. Manufacturers: One of the following or equal:
  - 1. Spears.
- B. Materials:
  - 1. Slip socket: Schedule 80 PVC.
  - 2. Collar: Type 316 stainless steel.
  - 3. Threaded insert: Type 316 stainless steel or as appropriate for piped fluid.

## **2.07 PIPE SADDLES**

- A. Manufacturers: One of the following or equal:
  - 1. Smith-Blair, Inc., Style 317.
  - 2. Romac Industries, Inc., Style 202S.
- B. Materials:
  - 1. Pipe saddles: Ductile iron.
  - 2. Straps, bolts, and nuts: Type 304 stainless steel with Teflon coating on nuts.
  - 3. Gaskets: Rubber.





## **2.08 TAPPING SLEEVES**

- A. Manufacturers: One of the following or equal:
  - 1. Smith-Blair, Inc., Style 622.
  - 2. Romac Industries, Inc., Style FTS 420.
- B. Materials:
  - 1. Tapping sleeves: Steel construction.
  - 2. Bolts and nuts: Type 304 stainless steel.
  - 3. Nuts: Teflon coated.
  - 4. Gaskets: Rubber
  - 5. Size of tapped boss: As indicated on the Drawings.

## **2.09 SPRAY NOZZLES**

- A. Design:
  - 1. Operating pressure 10 pounds per square inch gauge, at which pressure each nozzle discharges not less than 3.5 gallons per minute, nor more than 5.0 gallons per minute.
    - a. Spray: Flat, heavy sheet, fan with uniform distribution.
    - b. Fan width at the water surface not less than 6.5 feet at 10 pounds per square inch gauge.
    - c. Spray deflection with a replaceable deflector insert free to rotate away from the orifice opening and mechanically locked in place and counterweighted.
  - 2. Spray nozzles structurally suitable for pressure up to 200 pounds per square inch gauge.
  - 3. Nozzles, easy flush type.
- B. Materials:
  - 1. Spray nozzles: Lead bronze.
  - 2. Nozzles provided with 1/4 inch national pipe thread, and the orifice diameter not less than 1/4 inch.
  - 3. Replaceable spray deflector: Neoprene rubber.

## **2.10 SHIPPING**

- A. As specified in Section 01600 - Product Requirements.

# **PART 3 EXECUTION**

## **3.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements.
- B. Drawings supersede conflicts with this Section.
- C. Bellows type expansion joints and vibration control joints:
  - 1. Protect joints against damage during pressure test.



## 02 INSTALLATION

- A. Expansion control joints:
  - 1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
  - 2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
  - 3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
    - a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
  - 4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
  - 5. Provide control rods and additional guides where indicated on the Drawings, but at no greater intervals than recommended by the joint manufacturer in published instructions.
  - 6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.
- B. Expansion joints for steam cleaned piping:
  - 1. Install no less than 1 expansion joint in a run of steam cleaned piping which exceeds 20 feet in length.
    - a. Do not exceed 200 feet in spacing of expansion joints.
  - 2. Install expansion joints in steam cleaned piping between anchors.
- C. Steam connections for steam cleaned piping:
  - 1. Provide connections for steam service in steam cleaned piping where indicated on the Drawings.
  - 2. Locate connections for steam near an anchor and away from an expansion joint.
- D. Bellows type expansion joints for steam and hot water:
  - 1. Install not less than 1 expansion joint in a run of steam or hot water piping which exceeds 20 feet in length.
    - a. Do not exceed 150 feet spacing of expansion for steam piping and 200 feet for hot water piping.
  - 2. Where possible, install expansion joints adjacent to an anchor; provide piping with 2 concentric guides, the first being within 2 feet of the end of the joint opposite the anchor.
  - 3. At expansion joints not installed adjacent to an anchor, provide 2 concentric guides on piping within 2 feet off both ends of the expansion joint.
  - 4. Lock expansion joint against movement until pressure test is completed.
- E. Vibration control joints:
  - 1. Install vibration control joints at piping connections to or from mechanical equipment to prevent transmitting equipment vibration through the piping system.
- F. Transition couplings:
  - 1. Application:



- a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
2. Install transition-coupling products specifically designed and manufactured for that application.
- G. Pipe saddles:
  1. Coat threads on bolts with anti-gall coating prior to installation.
- H. Tapping sleeves:
  1. Verify existing pipe material and outer diameter prior to ordering materials.
  2. Coat threads on bolts with anti-gall coating prior to installation.
  3. Install gate valve between surge cushion and piping.
- I. Spray nozzles:
  1. Install spray nozzles so that elevation of the nozzles is 18 inches above the water surface.

### **3.03 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  1. Required only for:
    - a. Transition couplings.
    - b. Tapping sleeves for large diameter pipe.
  2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
  3. Provide Manufacturer's Representative Onsite:
    - a. Installation: 2 trip / 1 day each:
      - 1) Installation consultation and advice.
      - 2) Installation inspection.
- C. Field testing:
  1. As specified in Section 15052 - Common Work Results for General Piping.
  2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION





## SECTION 15121

### PIPE COUPLINGS - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Pipe couplings for ductile iron piping.
  - 2. Pipe couplings for carbon steel piping.
  - 3. Pipe couplings for stainless steel piping.

##### 1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. American Society of Mechanical Engineers (ASME):
  - 1. B31.1 - Power Piping.
  - 2. B31.9 - Building Services Piping.
- C. American Water Works Association (AWWA):
  - 1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - 2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
  - 3. C606 - Standard for Grooved and Shouldered Joints.
- D. ASTM International (ASTM):
  - 1. A36 - Standard Specification for Carbon Structural Steel.
  - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
  - 3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
  - 5. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
  - 6. A536 - Standard Specification for Ductile Iron Castings.
  - 7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  - 8. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
  - 9. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
  - 10. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- E. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.
  - 2. 372 - Drinking Water System Components - Lead Content.



1.03

## **SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. For each product in this Section as applicable:
    - a. Design features.
    - b. Load capacities.
    - c. Material designations by UNS alloy number or ASTM Specification and Grade.
    - d. Data needed to verify compliance with the Specifications.
    - e. Catalog data.
    - f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
- C. Calculations:
  - 1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

## **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements:
  - 1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.
- B. Known acceptable manufacturers are listed by specific products.
- C. Provide references as specified in this Section by specific product.
- D. Manufacturer's representatives requirements as specified in Section 01756 - Commissioning and this Section by specific product.
- E. Gaskets for flexible couplings and flanged coupling adapters:
  - 1. Provide gasket materials for piping applications as follows:
    - a. Low-pressure and high-pressure air, steam, hot water: EPDM.
    - b. All other piping applications: Neoprene rubber or Buna-N
- F. Exterior coatings for underground and submerged applications:
  - 1. Manufacturers: One of the following or equal:
    - a. Tapecoat Co., Inc., T.C. Mastic.
    - b. Kop-Coat Co., Inc., Bitumastic Number 50.
  - 2. Thickness: Minimum 0.040 inch.



## 2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

- A. Dismantling joints:
  - 1. Manufacturers: One of the following or equal:
    - a. Romac Ind., Inc., Style DJ400.
    - b. Smith-Blair, Inc., Series 975.
  - 2. Materials:
    - a. Flanged spool: AWWA C207 steel pipe:
      - 1) ASTM A53 for sizes 3 inches to 12 inches.
      - 2) ASTM A36 for sizes 14 inches to 72 inches.
    - b. End ring and body:
      - 1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
      - 2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36 or A53.
    - c. Follower ring: Ductile iron in accordance with ASTM A536.
    - d. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
    - e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.
  - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
  - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- B. Flanged coupling adapters: 12-inch size and smaller:
  - 1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 227.
    - b. Romac Ind., Inc., Style FCA501.
    - c. Smith-Blair, Inc., Series 912.
  - 2. Materials:
    - a. Flanged body: Ductile iron in accordance with ASTM A536.
    - b. Follower ring: Ductile iron in accordance with ASTM A536.
    - c. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  - 3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- C. Flanged coupling adapters: Greater than 12-inch size:
  - 1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 128-W.
    - b. Romac Ind., Inc., Style FC400.
    - c. Smith-Blair, Inc., Series 913.





2. Materials:
    - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - c. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- D. Flexible couplings:
1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 253.
    - b. Romac Ind., Inc., Style 501.
    - c. Smith-Blair, Inc., Series 441.
  2. Materials:
    - a. Center rings: Ductile iron in accordance with ASTM A536.
    - b. Follower rings: Ductile iron in accordance with ASTM A536.
    - c. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
  3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
  4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per Pipe Couplings for Steel Piping

- E. Restrained flange coupling adapter:
1. Manufacturers: One of the following or equal:
    - a. Romac Ind., Inc., Style RFCA.
    - b. Star Pipe Products, 3200 StarFlange™.
  2. Materials:
    - a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
    - b. Follower ring: Lug type restraint system.
      - 1) Follower ring: Ductile iron in accordance with ASTM A536.
      - 2) Restraining lugs: Ductile iron in accordance with ASTM A536.
        - a) Designed to contact the pipe and apply forces evenly.



- 3) Restraining bolts:
    - a) Ductile iron in accordance with ASTM A536.
    - b) Bolt heads shall be designed to twist off when the proper torque has been applied.
  - c. Bolts and hex nuts:
    - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
    - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
  5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.
- F. Grooved joint couplings:
1. Manufacturers: The following or equal:
    - a. Victaulic Co., Series 31 or equal.
  2. Materials:
    - a. Housings: Ductile iron in accordance with ASTM A536.
    - b. Gasket:
      - 1) BUNA-N.
    - c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
    - d. Coating: As specified in Section 09960 - High-Performance Coatings.
  3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
  4. For connection to IPS steel pipe sizes, Victaulic Style 307.

## **2.03 PIPE COUPLINGS FOR CARBON STEEL PIPING**

- A. Dismantling joints:
1. Manufacturers: One of the following or equal:
    - a. Romac Ind., Inc., Style DJ400.
    - b. Smith-Blair, Inc., Series 975.
  2. Materials:
    - a. Flanged spool:
      - 1) C207 Schedule 40 pipe in accordance with ASTM A53 for sizes 3 inches to 12 inches.
      - 2) Steel for pipe in accordance with ASTM A36 or A53 for sizes 14 inches to 72 inches.
    - b. End ring and body:
      - 1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
      - 2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36.
    - c. Follower ring: Ductile iron in accordance with ASTM A536 or steel in accordance with ASTM A36 or A576.
    - d. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.



- 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
    - e. Tie rods: High tensile steel in accordance with ASTM A193 grade B7.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Fusion bonded epoxy certified in accordance with NSF 61.
- B. Flanged coupling adapters:
  1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 128-W.
    - b. Romac Ind., Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
    - c. Smith-Blair, Inc., Series 913.
  2. Materials:
    - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - c. Bolts and hex nuts:
      - 1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- C. Flexible couplings:
  1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 38.
    - b. Smith-Blair, Inc., Series 411.
    - c. Romac Ind., Inc., Style 511 or Style 400.
  2. Materials:
    - a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - b. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.



4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Diameter	Sleeve Length
2-1/2 inch and smaller	Manufacturer's standard
3 inch through 6 inch	7 inch
8 inch through 14 inch	7 inch
Greater than 14 inches	10 inch

D. Restrained flange coupling adapters:

1. Manufacturers: One of the following or equal:
  - a. Romac Ind., Inc., Style RFCA.
  - b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
  - a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
  - b. Follower ring: Lug type restraint system.
    - 1) Follower ring: Ductile iron in accordance with ASTM A536.
    - 2) Restraining lugs: Ductile iron in accordance with ASTM A536.
      - a) Designed to contact the pipe and apply forces evenly.
    - 3) Restraining bolts: Ductile iron in accordance with ASTM A536. Bolt heads shall be designed to twist off when the proper torque has been applied.
  - c. Bolts and hex nuts:
    - 1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
    - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy certified in accordance with NSF 61.

E. Grooved joint couplings:

1. Model numbers from one manufacturer are shown to indicate type only. Equivalent products of other manufacturers may be submitted for approval.
2. Coating: As specified in Section 09960 - High-Performance Coatings.
3. Sizes through 12 inch:
  - a. Rigid type:
    - 1) Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
    - 2) 2 inch through 6 inch: Installation-ready, for direct stab installation without field disassembly, with grade EHP gasket rated to plus 250 degrees Fahrenheit.
    - 3) Manufacturers: One of the following or equal:
      - a) Victaulic Style 107.
      - b) Victaulic Zero-Flex Style 07.
  - b. Flexible type:
    - 1) For use in locations where vibration attenuation and stress relief are required.



- 2) Three flexible couplings may be used in lieu of a flexible connector.
- 3) The couplings shall be placed in close proximity to the source of the vibration.
- 4) Manufacturers: The following or equal:
  - a) Victaulic Style 77.
- c. Flange adapter:
  - 1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
  - 2) Manufacturers: The following or equal:
    - a) Victaulic Style 741.
4. Sizes 14 inch through 24 inch:
  - a. Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.
  - b. Rigid type:
    - 1) Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
    - 2) Manufacturers: The following or equal:
      - a) Victaulic Style W07.
  - c. Flexible type:
    - 1) Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
    - 2) Manufacturers: The following or equal:
      - a) Victaulic Style W77.
  - d. Flange adapter:
    - 1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
    - 2) Manufacturers: The following or equal:
      - a) Victaulic Style W741.
5. For sizes 30 inch and larger:
  - a. Manufacturers: The following or equal:
    - 1) Victaulic Style AGS multiple-segment housing may be used.

## **2.04 PIPE COUPLINGS FOR STAINLESS STEEL PIPING**

- A. Flexible couplings:
  1. Manufacturers: The following or equal:
    - a. Dresser, Inc., Style 38.
- B. Grooved joint couplings:
  1. Manufacturers: The following or equal:
    - a. Victaulic Co.
  2. Materials:
    - a. Housings:
      - 1) Ductile iron in accordance with ASTM A536.
      - 2) Stainless steel in accordance with ASTM A351.
    - b. Gasket: Elastomer in accordance with ASTM D2000.
    - c. Bolts and nuts:
      - 1) Electroplated steel in accordance with ASTM A449.
      - 2) Stainless steel in accordance with ASTM F593.

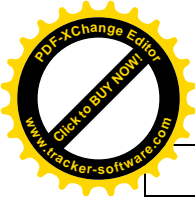


3. Rigid type:
    - a. Victaulic Style 89 and W89 (ductile iron housings).
    - b. Victaulic Style 489 (stainless steel housings).
  4. Flexible type: Victaulic Style 77S.
- C. Bolted, split-sleeve couplings:
1. Split-sleeve type pipe coupling with a fully stainless steel double arch cross section. Coupling shall be designed to close around the pipe ends, confining the gaskets beneath the arches of the sleeve. A watertight, axial seal is created by tightening the bolts to pull the coupling against the outside wall of the pipe.
  2. Manufacturers: One of the following or equal:
    - a. "Expansion x expansion" configuration:
      - 1) Victaulic, Depend-O-Lok, E x E, Type 2 Coupling.
    - b. "Fixed x expansion" configuration:
      - 1) Victaulic, Depend-O-Lok, F x E, Type 2 Coupling.
    - c. "Fixed x fixed" configuration:
      - 1) Victaulic, Depend-O-Lok, F x F, Type 2 Coupling.
    - d. "Fixed x fixed modified" configuration:
      - 1) Victaulic, Depend-O-Lok, F x F, Type 2 Modified Restrained Coupling.
  3. Materials:
    - a. Couplings: Stainless steel in accordance with ASTM A240.
    - b. Bolts and nuts: In accordance with ASTM F593 and ASTM F594.
  4. Pipe preparation:
    - a. Pipe ends shall be smooth for expansion or contraction requirements.
    - b. Where thrust restraint is required or is indicated on the Drawings, pipe ends shall include restraint rings affixed for pipe end restraint requirements.
    - c. The coupling manufacturer shall provide restraint rings that shall be shop welded to the pipe in accordance with the manufacturer's requirements.
    - d. Follow coupling manufacturer's recommendation for size and amount of welding required to attach the restraint rings to the pipe.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with manufacturer's instructions.
- B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.
- C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
  1. Install flexible coupling with pipe gap located in middle of center sleeve.
  2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.



Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

- D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
- E. Grooved joint couplings:
1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
  2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.
- F. Bolted, split-sleeve couplings:
1. Inspect each coupling to insure that there are no damaged portions of the coupling.
    - a. Pay particular attention to the sealing pad/sealing plate area.
    - b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all time.
  2. Wrenches:
    - a. Conform to manufacturer instructions.
    - b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
    - c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
  3. No joint shall be misfit in any plane.
  4. On the fixed ends of bolted, split-sleeve couplings, the shoulders shall bear on the restraint rings all around with no visible gap.
  5. Ends of piping where coupler are installed shall be smooth and free of defects.
    - a. Remove weld splatter and grind smooth.
    - b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION





## SECTION 15211

### DUCTILE IRON PIPE: AWWA C151 - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Ductile iron pipe, joints, connections, and fittings.
- A. As specified in Section 15052 - Common Work Results for General Piping - Plant.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. American Water Works Association (AWWA):
  - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
  - 2. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - 3. C115 - Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
  - 4. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
  - 5. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
  - 6. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
  - 7. C606 - Standard for Grooved and Shouldered Joints.
- C. American Welding Society (AWS):
  - 1. D11.2 - Guide for Welding Iron Castings.
- D. ASTM International (ASTM):
  - 1. A47 - Standard Specifications for Ferritic Malleable Iron Castings.
  - 2. A536 - Standard Specifications for Ductile Iron Castings.
- E. Ductile Iron Pipe Research Association (DIPRA):
  - 1. Thrust Restraint Design Manual.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.
- C. Shop drawings:
  - 1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
  - 2. Thrust restraint systems.



3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.
4. Pipe coatings and linings as specified in Section 09997 - Pipeline Coatings and Linings.

D. Calculations:

1. Calculations for thrust restraint system design.

E. Welded outlets:

1. Upon request, Contractor shall provide test results from the manufacturer indicating typical mechanical properties of the utilized weld material (an all-weld sample), as well as typical mechanical properties from transverse tensile and impact specimens machined from butt-weld joined ductile iron pipe coupons to show the suitability or equivalence of the electrodes used.
2. Manufacturer's air-test logs documenting air-leakage tests on all welded-on outlet pipes. Documentation of 500 pounds per square inch hydrostatic testing results may be provided as an alternative to air testing.
3. Proof test data confirming the design, hydrostatic test results, and safety factors for welded outlets.

F. Manufacturer's source testing.

#### **1.04 QUALITY ASSURANCE**

- A. Ductile iron pipe shall be supplied by a single manufacturer.
- B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURED UNITS**

- A. Ductile iron piping:
  1. Manufacturers
    - a. American Cast Iron Pipe Co.
    - b. Pacific States Cast Iron Pipe Co.
    - c. SIP Industries.
    - d. U.S. Pipe.

#### **2.02 DUCTILE IRON JOINTS AND CONNECTIONS**

- A. General:
  1. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052 - Common Work Results for General Piping.
  2. In accordance with AWWA C150 and AWWA C151.
  3. Joints:
    - a. Flanged.
    - b. Grooved.
    - c. Mechanical.
    - d. Push-on Rubber Gasket.
    - e. Integrally Restrained Mechanical.
    - f. Mechanical Wedge Action.



- g. Integrally Restrained Push-On.
- h. Push-On Joint Restraint Harness.
- 4. Connections:
  - a. Tapping saddle.
  - b. Tapping sleeve.
  - c. Welded outlet.
- 5. Fittings.

B. Joints:

- 1. Flanged joints:
  - a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
    - 1) Ductile iron.
    - 2) Long hub, threaded, and specially designed for ductile iron pipe.
    - 3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
  - b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
  - c. Cap screw or stud bolt holes: Tapped.
  - d. Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
  - e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052 - Common Work Results for General Piping.
- 2. Grooved joints: In accordance with AWWA C606, as complemented and modified below, radius-cut type, with following components:
  - a. Couplings: Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510.
  - b. Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
  - c. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
  - d. Fittings: In accordance with AWWA C606, rigid radius-cut groove:
    - 1) Center-to-center dimensions: In accordance with AWWA C110.
    - 2) Wall thickness and other characteristics: In accordance with AWWA C606.
  - e. Flanged unit connections: Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
- 3. Mechanical joints: In accordance with AWWA C111.
  - a. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
  - b. Bolts and nuts, including T-bolts: As specified in Section 15052 - Common Work Results for General Piping.
- 4. Push-on rubber gasket joints: In accordance with AWWA C111.
  - a. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
- 5. Mechanical wedge action joint restraints:
  - a. Manufacturers: One of the following or equal:
    - 1) EBAA Iron, Inc., Megalug® Series 1100.
    - 2) Star Pipe Products, Split Stargrip Series 3000.
    - 3) Sigma Corp., One-Lok Model SLDE.



- b. Materials:
    - 1) Gland body: Ductile iron in accordance with ASTM A536.
    - 2) Wedges and wedge actuating components: Ductile iron in accordance with ASTM A536.
      - a) Wedges shall be heat treated to a minimum of 370 BHN.
    - 3) Actuating bolts and nuts: Ductile iron in accordance with ASTM A536.
      - a) Provide torque-limiting twist off components to ensure proper installation.
    - 4) Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
  - c. Coatings:
    - 1) Provide manufacturer applied coating system.
    - 2) Manufacturers: One of the following or equal:
      - a) EBAA Iron Inc., Mega-Bond.
      - b) Star Pipe Products, Star-Bond.
      - c) Sigma Corp., Corrsafe™ Electro-deposition coating.
  - d. Working pressure:
    - 1) Shall include a minimum safety factor of 2:1.
    - 2) For sizes 3- through 16-inch: 350 pounds per square inch.
    - 3) For sizes 18- through 48-inch: 250 pounds per square inch.
  - e. Restraint shall consist of multiple gripping wedges incorporated into a follower gland meeting the requirements of AWWA C111.
  - f. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
  - g. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.
6. Push-on joint restraint harnesses:
- a. Manufacturers: One of the following or equal:
    - 1) EBAA Iron, Inc., Megalug® Series 1700.
    - 2) Star Pipe Products, Split Stargrip Series 3100S.
    - 3) Sigma Corp., One-Lok Model SLDEH.
  - b. Materials:
    - 1) Restraint and backup ring: Ductile iron in accordance with ASTM A536.
    - 2) Wedges and wedge actuating components: Ductile iron in accordance with ASTM A536.
      - a) Wedges shall be heat treated to a minimum of 370 BHN.
    - 3) Actuating bolts and nuts: Ductile iron in accordance with ASTM A536.
      - a) Provide torque-limiting twist off components to ensure proper installation.
    - 4) Tie rods: Low alloy steel in accordance with AWWA C111.
    - 5) Bolts and nuts, including T-bolts: As specified in 15052 - Common Work Results for General Piping.
  - c. Coatings:
    - 1) Provide manufacturer applied coating system.
    - 2) Manufacturers: One of the following or equal:
      - a) EBAA Iron Inc., Mega-Bond.
      - b) Star Pipe Products, Star-Bond.
      - c) Sigma Corp., Corrsafe™ Electro-deposition coating.



- d. Working pressure:
  - 1) Shall include a minimum safety factor of 2:1.
  - 2) For sizes 3- through 16-inch: 350 pounds per square inch.
  - 3) For sizes 18- through 48-inch: 250 pounds per square inch.
- e. Restraint shall consist of a backup ring behind the ductile iron bell and a restraint ring consisting of multiple gripping wedges connected with number and type of tie rods as recommended by the manufacturer.
- f. Restraint shall allow post assembly deflection of a minimum of 50 percent of the deflection capability of the push-on joint.

C. Connections:

- 1. Tapping saddle as specified in Owner standard specification.
- 2. Tapping sleeve as specified in Owner standard specification.
- 3. Welded outlet.
  - a. Provide weld-on outlets as indicated on the Drawings.
  - b. Fabrication:
    - 1) Welded outlets shall be fabricated by the pipe manufacturer at the same facility where the pipe is produced.
    - 2) Application is limited to branch outlets having a nominal diameter not greater than 70 percent of the nominal diameter of the main line pipe or 36 inches.
    - 3) Parent pipe and branch outlet candidate pipe shall be centrifugally cast ductile iron pipe designed in accordance with AWWA C150 and manufactured in accordance with AWWA C151. Minimum classes for parent and outlet pipe:
      - a) Sizes 4- through 54-inch: Special Thickness Class 53.
      - b) Sizes 60- through 64-inch: Pressure Class 350.
    - 4) Electrodes for reinforcing welds:
      - a) Manufacturers: One of the following or equal:
        - (1) NCO Alloys, Ni-Rod 55-0 flux cored wire.
        - (2) INCO Alloys, Ni-Rod 55 welding electrode.
        - (3) Stooddy Castweld, Ni 55-0 flux cored wire.
        - (4) INCO Alloys, Ni-Rod 44 Filler Metal.
      - b) Carbon steel electrodes are not acceptable.
- c. Pressure rating:
  - 1) Welded outlets 6- through 30-inch: Rated for a working pressure of 250 pounds per square inch.
  - 2) Welded outlets 36-inch and larger: Rated for 200 pounds per square inch.
  - 3) Welded outlets of all diameters and configurations:
    - a) Have a minimum safety factor of 2.0 based on proof of design hydrostatic test results.
    - b) The Contractor shall, at the request of Engineer, provide the manufacturer's representative proof test data confirming the design, hydrostatic test results, and safety factors.
- d. Source quality control:
  - 1) Branch outlets shall be subjected to an air pressure test of at least 15 pounds per square inch.
    - a) Air leakage is not acceptable.



- b) Any leakage shall be detected by applying an appropriate foaming solution to the entire exterior surface of the weldment and adjoining pipe edges or by immersing the entire area in a vessel of water and visually inspecting the weld surface for the presence of air bubbles.
    - c) Hydrostatic testing to 500 pounds per square inch on each branch outlet can be used in lieu of air testing.
    - d) Any weldment that shows any signs of leakage shall be repaired and retested in accordance with the manufacturer's written procedures.
  - 2) Pipe manufacturer shall have a fully documented welding quality assurance system and maintain resident quality assurance records in accordance with AWS D11.2.
  - 3) Pipe manufacturer shall maintain appropriate welding procedure specification, procedure qualification, and welder performance qualification test records as well as appropriate air-test logs documenting air-leakage tests on all welded-on outlet pipes furnished to the Project.
- D. Fittings:
  - 1. Ductile iron in accordance with AWWA C110.
  - 2. Joint type: Same as that of the associated piping as specified in Section 15052 - Common Work Results for General Piping.
  - 3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. General:
  - 1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 15052 - Common Work Results for General Piping.
  - 2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318 - Trenching.
- B. Joints:
  - 1. Install types of joints as specified in the piping schedule provided in Section 15052 - Common Work Results for General Piping.
  - 2. Mechanical joints are not acceptable in above ground applications.
  - 3. Field closure for restrained push-on pipe:
    - a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
  - 4. Grooved joints:
    - a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 - Common Work Results for General Piping.
    - b. Assemble grooved joints in accordance with manufacturer's published instructions.
    - c. Support grooved-end pipe in accordance with manufacturer's published instructions.
      - 1) Install at least 1 support between consecutive couplings.



C. Connection:

1. Tapping ductile iron pipe:
  - a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
    - 1) Maximum allowable tap diameter by pipe diameter and pressure class:
  - b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
  - c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.
2. Direct tapping of glass lined ductile iron pipe may be performed only when approved in writing by the Engineer. Direct tapping of glass lined pipe shall be performed in accordance with the above conditions for tapping ductile iron pipe in addition to the following conditions:
  - a. Drilling and tapping shall be performed using a hole saw.
    - 1) Use of a large drill bit is not acceptable.
  - b. As the hole saw approaches the glass lining, lessen the inward pressure to avoid excess chipping or cracking of the lining.
  - c. Minor chipping or spalling of the glass lining shall be repaired using an epoxy resin "glass repair kit" provided by the fabricator.
    - 1) Manufacturers: One of the following or equal:
      - a) Devoe - Devran 224 HS.
      - b) Sherwin-Williams Co. - Sher-Tile High Solids Epoxy.
    - 2) Repair kit use is only allowed for areas of damage less than 1/2 inch in diameter.
      - a) Larger areas of damage will require replacement.
    - 3) Surface shall be prepared and repair kit shall be applied in accordance with manufacturer and/or fabricator's instructions.

### 3.02 FIELD QUALITY CONTROL

A. Testing ductile iron piping:

1. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION







## SECTION 15249

### POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Schedule type PVC pipe and fittings.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  - 2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
  - 3. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
  - 4. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
  - 5. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
  - 6. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
  - 7. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
- B. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.
- C. Store and handle as recommended by manufacturer in published instructions.



## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
  - 1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
    - a. Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
    - b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
  - 2. Fittings: In accordance with ASTM D2467.
    - a. Same material as the pipe and of equal or greater pressure rating.
    - b. Supplied by pipe manufacturer.
    - c. Unions 2-1/2 inches and smaller:
      - 1) Use socket end screwed unions.
    - d. Unions 3 inches and larger:
      - 1) Use socket flanges with 1/8-inch full-face soft EPDM gasket.
  - 3. Solvent cement:
    - a. In accordance with ASTM D2564.
    - b. Manufacturers: The following or equal:
      - 1) IPS Corp.
    - c. Certified by the manufacturer for the service of the pipe.
    - d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.
    - e. Primer: As recommended by the solvent cement manufacturer.

### **2.02 SOURCE QUALITY CONTROL**

- A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.
- B. Provide molded transition fittings for transitions from plastic to metal pipe.
  - 1. Do not thread pipe.
- C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
- D. Provide serrated nipples for transition from pipe to rubber hose.
- E. Solvent weld joints in accordance with ASTM D2855.



### **3.02 FIELD QUALITY CONTROL**

- A. Test pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 15259

### CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE: ASTM F441

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: ASTM F441 CPVC pipe and fittings.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  2. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
  3. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
  4. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
  5. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
  6. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

##### 1.03 ABBREVIATIONS

- A. CPVC: Chlorinated polyvinyl chloride.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

#### PART 2 PRODUCTS

##### 2.01 MATERIALS

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
- B. Pipe:
  1. In accordance with ASTM F441 and Appendix, CPVC 4120.
  2. Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D1784.
  3. Schedule 80, unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.



4. Manufacturers: One of the following or equal:
  - a. Charlotte Pipe and Foundry Co.
  - b. Eslon Thermoplastics, Inc.
  - c. GF Harvel.
  - d. Spears Manufacturing Co.
  - e. Chemtrol.
- C. Fittings:
  1. In accordance with ASTM F438 or ASTM F439 for pressure fittings, as appropriate to the service and pressure requirement.
  2. Same material as the pipe and of equal or greater pressure rating.
  3. Supplied by pipe manufacturer.
- D. Solvent cement:
  1. In accordance with ASTM F493.
  2. Manufacturers: The following or equal:
    - a. IPS Corp.
  3. Certified by the manufacturer for the service of the pipe.
  4. Primer: As recommended by the solvent cement manufacturer.
- E. Unions 2-1/2 inches and smaller:
  1. Socket end screwed unions.
- F. Unions 3 inches and larger:
  1. Socket flanges with 1/8-inch full-face soft Viton gasket.

## **2.02 SOURCE QUALITY CONTROL**

- A. Mark pipe and fittings in accordance with ASTM F441.

## **PART 3 EXECUTION**

### **3.01 DELIVERY, STORAGE, AND HANDLING**

- A. Protect from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.
- C. Store and handle as recommended by manufacturer in published instructions.

### **3.02 INSTALLATION**

- A. General:
  1. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
  2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe.
    - a. Do not thread pipe.
  3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
  4. Provide serrated nipples for transition from plastic pipe to rubber hose.





- B. Installation of piping:
1. Clean dirt and moisture from pipe and fittings.
  2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file.
    - a. Remove burrs.
  3. Use solvent cement and primer formulated for CPVC.
  4. Use primer on pressure and non-pressure joints.
  5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

### **3.03 FIELD QUALITY CONTROL**

- A. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 15270

### STEEL PIPE: ASTM A53 - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Steel pipe: Galvanized and black, ASTM A53.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
  - 2. B16.5 - Pipe Flanges and Flanged Fittings.
  - 3. B16.9 - Factory-Made Wrought Buttwelding Fittings.
- B. American Water Works Association (AWWA):
  - 1. C110 - Ductile-Iron and Gray-Iron Fittings.
  - 2. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines- Enamel and Tape-Hot Applied.
  - 3. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 Inches and Larger-Shop Applied.
  - 4. C206 - Field Welding of Steel Water Pipe.
  - 5. C602 - Standard for Cement-Mortar Lining of Water Pipelines in Place- 4 inches and Larger.
  - 6. C606 - Standard for Grooved and Shouldered Joints.
- C. ASTM International (ASTM):
  - 1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
  - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
  - 3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
  - 4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 5. A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
  - 6. A536 - Standard Specification for Ductile Iron Castings.
  - 7. C150 - Standard Specification for Portland Cement.
  - 8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.



## ART 2 PRODUCTS

### 2.01 MATERIALS

- A. Portland cement: In accordance with ASTM C150, Type II, low alkali.

### 2.02 MANUFACTURED UNITS

- A. Steel pipe:
1. General:
    - a. In accordance with ASTM A53.
      - 1) Type: Type E - electric-resistance welded or Type S - seamless.
      - 2) Grade: Grade A or B.
    - b. Schedule:
      - 1) As indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
      - 2) Minimum Schedule unless otherwise indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule:
        - a) Pipe 6 inches and smaller: Schedule 40.
        - b) Pipe greater than 6 inch to 12 inch: Schedule 20.
        - c) Pipe greater than 12 inch: 0.25 inches.
- B. Pipe fittings:
1. Flanged and welding fittings:
    - a. Butt-weld fittings in accordance with ASME B16.9.
    - b. Schedule of fittings: Same class or thickness as the pipe to which it connects.
  2. Screwed fittings:
    - a. Malleable iron:
      - 1) Class 150 or Class 300 in accordance with ASME B16.3, as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
      - 2) Galvanized in accordance with ASTM A153 where used with galvanized pipe.
  3. Grooved joint fittings:
    - a. Fittings for grooved joint steel piping: Rigid-grooved type.
    - b. Fittings for grooved joint piping:
      - 1) Manufacturers: One of the following or equal:
        - a) Victaulic Co. of America.
        - b) Grinnell.
        - c) Anvil.
      - 2) Ductile iron fittings:
        - a) Larger than 4 inches in diameter: In accordance with ASTM A536, Grade 65-45-12, long radius, per AWWA C110.
        - b) Less than 4 inches in diameter: Malleable iron conforming to ASTM A47, Grade 32510.
      - 3) Where cast fittings are not made, forged steel in accordance with ASME B 16.9, ASTM A105, Grade B with 0.375 inch minimum wall thickness.
        - a) Bends: Long radius.



- 4) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint coupling.
- 5) Fittings for grooved joint piping shall be for rigid-grooved type joints. Connection to flanged units shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items, minimum length, 4 inches.

C. Pipe joints:

1. General:

- a. Use type of pipe joints as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
- b. In addition to the type of pipe joints indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule, use flexible couplings, unions or flanged joints to allow ready assembly and disassembly of the piping.

2. Flanged joints:

- a. In accordance with ASME B16.5, steel, 150 pounds, slip-on or weld neck, galvanized in accordance with ASTM A153 where used with galvanized pipe.
- b. Companion flanges:
  - 1) In accordance with ASME B16.5, steel.
  - 2) Class 150 pounds, slip-on or welding neck.
- c. Weld flanges to pipe or fittings before applying lining.
- d. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
- e. Match pipe flanges to the valve flanges.
- f. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
- g. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

3. Grooved joints:

- a. Grooves: Cut grooves. Rolled grooves are not acceptable.
- b. Couplings housing: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
- c. Bolts and nuts: In accordance with ASTM A183, Grade 2.
- d. Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
  - 1) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
  - 2) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of neoprene in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
- e. Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
  - 1) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
  - 2) Shoulder: Type B or D in accordance with AWWA C606.



- f. Couplings and grooving:
        - 1) Manufacturers: One of the following or equal:
          - a) Victaulic Co.
          - b) Grinnell.
          - c) Anvil.
      - g. Grooved joint piping shall not be used in the following installations:
        - 1) In underground and underwater installations.
        - 2) In piping subject to test pressures of 150 pounds per square inch gauge, or more.
        - 3) In steam and gas piping.
        - 4) In sludge and scum piping designed to be steam cleaned.
    - 4. Welded joints: Butt welds, 2 pass, full depth with beveled ends and no backing rings.
  - D. Pipe lining and coating:
    - 1. General:
      - a. Lining and coating shall be as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping.
    - 2. Pipe coating:
      - a. Extend pipe coating for underground piping 6 inches above finish grade or finish floor, and neatly terminate.
      - b. Field paint aboveground steel pipe as specified in Execution of this Section.
      - c. Coat exposed piping as specified in Section 09960 - High-Performance Coatings.
      - d. Coat submerged piping as specified in Section 15052 - Common Work Results for General Piping pipe schedule and Section 09960 - High-Performance Coatings.
      - e. Cement-mortar coating:
        - 1) Cement-mortar coating: In accordance with AWWA C205, modified as follows:
          - a) Sand: In accordance with AWWA C205 except that the total percentage of deleterious material shall not exceed 3 percent.
      - f. Plastic tape wrap: As specified in Section 15274 - Plastic Tape Wrap for Pipe.
        - 1) For buried pipe, wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat, total thickness of tape 80 mils.
    - 3. Pipe lining:
      - a. Cement-mortar lining:
        - 1) Shop apply cement-mortar lining in accordance with AWWA C205. At the option of Contractor, field apply with a pipe lining machine.
      - b. Coal-tar enamel lining:
        - 1) Coal-tar enamel lining for interior of steel pipe: In accordance with AWWA C203.
      - c. Coal-tar epoxy lining:
        - 1) Coal-tar epoxy lining: Epoxy bituminous coating as specified for submerged metal in Section 09960 - High-Performance Coatings.
      - d. Fusion epoxy:
        - 1) Fusion bonded epoxy as specified for submerged metal or exposed metal in Section 15057 - Fusion Bonded Epoxy Lining.



- e. High solids epoxy:
  - 1) High solids epoxy as specified for submerged metal or exposed metal in Section 09960 - High-Performance Coatings.
- f. Polyurethane lining:
  - 1) Polyurethane as specified for submerged metal in Section 09960 - High-Performance Coatings.

## **2.03 FABRICATION**

- A. Shop coat of primer:
  - 1. Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
  - 2. Primer compatible with finish coating system.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Pipe joints:
  - 1. General:
    - a. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is as specified in Section 15052 - Common Work Results for General Piping pipe schedule or as indicated on the Drawings.
    - b. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
    - c. Unless otherwise indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule, pipe joints shall be as follows:
      - 1) Pipe smaller than 2 inches in nominal diameter shall have screwed joints, welded joints, unions, or flexible couplings.
      - 2) Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
      - 3) Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.
  - 2. Flanged joints:
    - a. Flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
    - b. Secure welding neck flanges with full penetration butt welds without backing rings.
    - c. Secure slip-on flanges with both internal and external welds.
    - d. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.
  - 3. Grooved joints:
    - a. Assemble in accordance with manufacturer's published instructions.
    - b. Support grooved joint pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.





4. Screwed joints:
    - a. Perform threading with clean, sharp dies.
      - 1) Wavy, rough, or otherwise defective pipe threads are not acceptable.
    - b. Make screwed joints tight and clean with an application of Teflon™ tape or paste compound applied to the male threads only, except as follows:
      - 1) Make up liquid and liquefied petroleum gas lines, with litharge and glycerin.
    - c. Provide railroad type unions with bronze-to-iron seat. Galvanized where used with galvanized pipe.
      - 1) Flanged joints may be used instead of unions.
  5. Welded joints:
    - a. Field welded joints: Electric arc welded in accordance with AWWA C206.
    - b. Welder's qualification: Qualified in accordance with AWWA C206.
      - 1) Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
    - c. Do not weld galvanized pipe.
- B. Pipe lining and coating:
1. Pipe lining:
    - a. Field applied cement-mortar lining shall be of the same density, smoothness, and thickness as shop applied lining, and in accordance with AWWA C602.
  2. Pipe Coating:
    - a. Plastic tape wrap application:
      - 1) Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat.
      - 2) Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape as specified in this subparagraph.
    - b. Field coat aboveground steel pipe as specified in Section 09960 - High-Performance Coatings.

### **3.02 FIELD QUALITY CONTROL**

- A. Field test fabricated steel manifolds with the pipe to which they connect.

END OF SECTION



## SECTION 15274

### PLASTIC TAPE WRAP FOR PIPE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Plastic tape wrap for pipe.

##### 1.02 REFERENCES

- A. American Water Works Association (AWWA):
  - 1. C209 - Standard for Cold-Applied Tape Coating for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
  - 2. C214 - Standard for Tape-Coating Systems for the Exterior of Steel Water Pipelines.
- B. National Association of Corrosion Engineers (NACE):
  - 1. RP0274-74 - Standard Recommended Practice.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data.

#### PART 2 PRODUCTS

##### 2.01 MANUFACTURED UNITS

- A. Plastic tape wrap for exterior of steel pipe, fittings and specials:
  - 1. In accordance with AWWA C209 and AWWA C214.
  - 2. Tape coating system:
    - a. Consist of the following:
      - 1) Primer.
      - 2) First layer of spirally applied 20 mil inner wrap.
      - 3) Middle layer of spirally applied 30 mil outer wrap.
      - 4) Finish layer of spirally applied 30 mil outer wrap.
      - 5) Minimum total coating thickness of 80 mils.
    - b. All materials shall be of products of the same manufacturer.
  - 3. Primer:
    - a. Manufacturers: The following or equal:
      - 1) Polyken Pipeline Coatings, Number 1019 or 1027 Primer.
      - 2) The Tapecoat Co., TC Omniprime Primer.
  - 4. Pipe wrap:
    - a. First wrap:
      - 1) Manufacturers: The following or equal:
        - a) Polyken Pipeline Coatings, Number 980-20 (932-50 for fittings).



- b. Middle wrap:
  - 1) Manufacturers: The following or equal:
    - a) Polyken Pipeline Coatings, Number 955-30.
- c. Finish wrap:
  - 1) Manufacturers: The following or equal:
    - a) Polyken Pipeline Coatings, Number 955-30 White.
- 5. Filler tape:
  - a. Manufacturers: The following or equal:
    - 1) Polyken, Number 939.
- 6. Joint wrap:
  - a. Manufacturers: The following or equal:
    - 1) Polyken, Number 932-50, white Hi-Tack Joint Wrap tape.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Plastic tape wrap application procedures shall be in accordance with manufacturer's published instructions.
  - 1. Apply plastic tape wrap in accordance with AWWA C209.
  - 2. Apply primer with brush, without runs and drips.
  - 3. Lap wrapping not less than 1/2-inch. A single wrap lapped 50 percent or more will not be acceptable.
  - 4. Application on welded joints:
    - a. Remove sharp edges of weld spatter and slag with a file or ball peen hammer before wrapping welded joints.
    - b. Clean and prime all surfaces:
      - 1) Then apply a wrap of 0.125-inch thick by 2 inches wide filler tape centered on the weld.
      - 2) Push and knead the tape into all voids.
      - 3) Start first wrapping 4 inches back on the pipe wrap, spiral wrap tape over the welded joint holding the proper tension and overlap, and finish 4 inches back on the pipe wrap on the other side of the joint.
    - c. Apply 2 wraps of 30 mil joint tape, or the tape may be half lapped to obtain the double thickness.
    - d. Apply finish wrapping in same manner.
  - 5. Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat for a total thickness of 80 mils.
  - 6. Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape.



### 3.02 FIELD QUALITY CONTROL

- A. Holiday detection testing:
  - 1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with plastic tape wrap prior to burying.
    - a. Perform high voltage electrical inspection in accordance with NACE RP0274-74.
    - b. Test voltage used for the electrical inspection of the piping and fittings shall be in accordance with the recommendations given by the tape coating manufacturer in their published literature.
    - c. Repair all holidays and defects found in the coating system by high voltage electrical inspection in accordance with the tape coating manufacturer's recommendations.
    - d. Retest repaired areas in the coating prior to burial of the piping.
  - 2. Before conducting holiday detection testing on any piping systems, submit technical literature and data describing the testing instrumentation, equipment, electrodes, and other accessories that will be used.
    - a. The literature and data shall include complete information covering the operation and use of the testing equipment, including operational voltage ranges.
  - 3. All holiday detection testing and coating repair work shall be witnessed and inspected by the Engineer.

END OF SECTION





## SECTION 15286

### STAINLESS STEEL PIPE AND TUBING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Stainless steel piping and tubing.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
  2. B16.11 - Forged Fittings, Socket-Welded and Threaded.
  3. B31.3 - Process Piping.
  4. B36.19 - Stainless Steel Pipe.
- B. American Welding Society (AWS):
1. D1.6 - Structural Welding Code - Stainless Steel.
- C. ASTM International (ASTM):
1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
  2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  3. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
  4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
  5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
  6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
  7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
  8. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
  9. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  10. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
  11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
  12. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
  13. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.



14. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
15. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
16. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
17. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
18. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

### **1.03 DESIGN REQUIREMENTS**

- A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
  1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
  2. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.
- B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.
- C. Field assembly:
  1. Field welding is prohibited.

### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.
- C. Shop drawings:
  1. Detailed layout drawings:
    - a. Dimensions and alignment of pipes.
    - b. Location of valves, fittings, and appurtenances.
    - c. Location of field joints.
    - d. Location of pipe hangars and supports.
    - e. Connections to equipment and structures.
    - f. Location and details of shop welds.
  2. Thickness and dimensions of fittings and gaskets.
  3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
  4. Material specifications for pipe, gaskets, fittings, and couplings.
  5. Data on joint types and components used in the system including flanged joints, grooved joint couplings and screwed joints.





## PART 2 PRODUCTS

### 2.01 STAINLESS STEEL PIPE

- A. General:
  - 1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.
- B. Wall thickness:
  - 1. As specified in Section 15052 - Common Work Results for General Piping.
  - 2. Piping 3 inches in nominal diameter and greater:
    - a. For general service applications with pressures less than 250 pounds per square inch gauge, pipe diameter 24-inches or less, minimum wall thickness corresponding to Schedule 10S.
    - b. For pressures exceeding 250 pounds per square gauge, minimum wall thickness corresponding to Schedule 40S.
  - 3. Piping less than 3 inches in nominal diameter:
    - a. Piping with threaded or grooved joints:
      - 1) Minimum wall thickness corresponding to Schedule 40S.
- C. Piping material and manufacturing:
  - 1. Comply with the requirements outlined in the following table:
- D. Fittings for piping 3 inches in nominal diameter and greater:
  - 1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
  - 2. Manufacturing standard: In accordance with ASTM A774.
  - 3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
  - 4. End configuration: As needed to comply with specified type of joint.
  - 5. Dimensional standards:
    - a. Fittings with weld ends: In accordance with ASME B16.11.
    - b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.
- E. Fittings for piping less than 3 inches in diameter:
  - 1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
  - 2. Manufacturing standard: In accordance with ASTM A403, Class WP.
  - 3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
  - 4. End configuration: As needed to comply with specified type of joint.
  - 5. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials.
- F. Piping joints:
  - 1. Joint types, piping greater than 2 inches in diameter, general:
    - a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
    - b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:



- 1) Piping stub ends with backing flanges.
- 2) Welded joints.
- 3) Flanged joints.
- 4) Grooved joints.
- c. Joints at valves and pipe appurtenances:
  - 1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
  - 2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters or flanged joints.
    - a) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system, and conforming to requirements as specified in Section 15121 - Pipe Couplings and External Joint Restraints.
- d. Joints in digester gas, ozone and oxygen piping systems, membrane and reverse osmosis filtration systems:
  - 1) Aboveground piping: Welded, flanged, or grooved, or stub ends with backing flanges.
  - 2) Underwater piping: Welded or flanged.
  - 3) Buried piping: Welded or mechanically restrained.
2. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, welded or screwed with Teflon tape thread lubricant.
3. Welded joints:
  - a. Pipe 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
  - b. Piping 4 inches through 12 inches in diameter: Double butt welded joints.
  - c. Piping less than 4 inches in diameter: Single butt-welded joints.
  - d. Mark each weld with a symbol that identifies the welder.
4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.
5. Piping stub ends and backing flanges for pipe 3 inches and larger:
  - a. Piping stub ends: Cast stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions.
    - 1) Manufacturers: The following or equal:
      - a) Alaskan Copper Works, Figure SK-38.
  - b. Backing flanges: Forged or plate stainless steel (type to match pipe material) with drilled bolt patterns in accordance with ASME B16.1, Class 125 or ASME B16.5, Class 150, 300 or 600, as scheduled.
    - 1) Manufacturers: The following or equal:
      - a) Alaskan Copper Works, Figure SK-39 (tube) or SK-39P (pipe).
  - c. Stub ends and backing flanges are not allowed for use with wafer style or lugged style valves.
6. Flanges for Schedule 40S and Schedule 80S pipe:
  - a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
  - b. Material: In accordance with ASTM A182.
- G. Gaskets:
  1. Ozone and oxygen service: TFE sheet.
  2. Aeration air service: As specified in Section 15052 - Common Work Results for General Piping.



3. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.
- H. Bolts for flanges and stub end/backing flanges:
  1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head.
    - a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
    - b. Nuts: In accordance with ASTM A194 heavy hex pattern.
- I. Fabrication of pipe sections:
  1. Welding: Weld in accordance with ASME B31.3.
  2. Weld seams:
    - a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
    - b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
    - c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
    - d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.
- J. Cleaning (pickling) and passivation:
  1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
  2. Clean (pickle) and passivate in accordance with ASTM A380 or A967.
    - a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
      - 1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
    - b. Passivation treatments with citric acid are not allowed.
  3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

## **2.02 STAINLESS STEEL TUBING**

- A. Stainless steel tubing:
  1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A269, wall thickness not less than 0.035 inch.
- B. Fittings: Swage ferrule design:
  1. Components made of:
    - a. Type 316 stainless steel.
  2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
  3. Flare type fittings are not acceptable.
  4. Manufacturers: One of the following or equal:
    - a. Crawford Fitting Co., Swagelok.
    - b. Hoke, Gyrolok.
    - c. Parker, CPI.
- C. Valves for use with stainless steel tubing:
  1. Ball type valves with swage ends to match tubing diameter.



2. Constructed from:
  - a. Type 316 stainless steel with TFE seats.
3. Manufacturers: The following or equal:
  - a. Crawford Fitting Co., Swagelok.

## **2.03 SOURCE QUALITY CONTROL**

- A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.
- B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.
- C. Provide written certification that the fittings as supplied are in accordance with ASTM A774.
  1. Supplementary testing is not required.
- D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.
- E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.
- F. Shipment to site:
  1. Protect all flanges and pipe ends by encapsulating in dense foam.
  2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
  3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
  4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
  5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
  6. Engineer may reject material due to improper shipping methods or damage during shipment.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install piping in such a manner as not to impart strain to connected equipment.
- B. Slope horizontal lines so that they can be drained completely.
- C. Provide valve drains at low points in piping systems.
- D. Install eccentric reducers where necessary to facilitate draining of piping system.
- E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.



### **3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS**

- A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

### **3.03 FIELD QUALITY CONTROL**

- A. Test piping to pressure and by method as specified in Section 15052 - Common Work Results for General Piping.
  - 1. If pressure testing is accomplished with water:
    - a. Use only potable quality water.
    - b. Piping: Thoroughly drained and dried or place immediately into service.
- B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

### **3.04 PROTECTION**

- A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
  - 1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
  - 2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
  - 3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without protection from bad weather is prohibited.
  - 4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION





## **SECTION 15294**

### **RUBBER HOSE**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Hose.

##### **1.02 SUBMITTALS**

- A. Product data: Manufacturer's data indicating service type, sizes, materials, and required accessories.

#### **PART 2 PRODUCTS**

##### **2.01 HOSE**

- A. Hose material: Neoprene or acceptable oil resistant material suitable for a working pressure of minimum 500 pounds per square inch, gauge.
- B. Size as indicated on the Drawings fit ends with appropriate combination clamped nipples and threaded ends as indicated on the Drawings.
- C. Hose larger than 1-1/2 inches in size: Industrial fire hose. Provide one 50-foot long hose for each utility station (hose bib and hose rack) provided.
  - 1. Manufacturers: One of the following or equal:
    - a. Goodyear Rubber Products Corp.
    - b. Uniroyal, Inc.
    - c. Goodall Rubber Co.
- D. Hose 1/2-inch through 1-1/2 inch nominal diameter: General purpose hose. Provide one 75 foot long hose for each utility station (hose bib and hose rack) provided.
  - 1. Manufacturers: One of the following or equal:
    - a. Goodyear Rubber Products Corp.
    - b. Uniroyal.
    - c. Goodall Rubber Co.
- E. Equip and fit hose ends with appropriate combination clamped nipples and threaded ends to make up the assembly indicated on the Drawings.

#### **PART 3 EXECUTION**

##### **3.01 INSTALLATION**

- A. Install hose in accordance with manufacturer's published instructions.

**END OF SECTION**







## SECTION 15521

### HOT WATER SYSTEM COMPONENTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Air separator.
  - 2. Pump discharge valve.
  - 3. Pump suction diffuser.
  - 4. Three-way temperature control valves.
  - 5. Automatic air vents.
- B. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.

##### 1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. American Society of Mechanical Engineers (ASME):
  - 1. Boilers and Pressure Vessels Code. Section VIII - Rules for Construction of Pressure Vessels Division 1.
- C. Instrument Society of Automation (ISA):
  - 1. 75.02.01 - Control Valve Capacity Test Procedures.
- D. National Fire Protection Association (NFPA):
  - 1. 54 - National Fuel Gas Code.
  - 2. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

##### 1.03 SYSTEM DESCRIPTION

- A. Provide all appurtenances necessary for a complete and functioning hot water control loop system, including but not limited to valves, piping, expansion tank, air vents, and drains.
  - 1. Contractor to coordinate with equipment provided in related Sections to ensure a complete functioning system as indicated on the Drawings.
- B. Design requirements:
  - 1. Water piping, drains, and venting: As specified in Section 01410 - Regulatory Requirements and in accordance with NFPA 54, and NFPA 90A.
  - 2. Control valves:  $C_v$  rated in accordance with ISA 75.02.01.
- C. Performance requirements:
  - 1. Performance requirements are included on the individual equipment schedules.



## **1.04 SUBMITTALS**

- A. Shop drawings:
  - 1. The following shall be submitted as specified in Section 01330 - Submittal Procedures and Section 15050 - Common Work Results for Mechanical Equipment:
    - a. Shop drawings for 3-way control valves:
      - 1) Include connection details with the submittals.
      - 2) System layout drawings.
      - 3) Process schematics.
    - b. For all system components:
      - 1) Make, model, and weight of each equipment assembly.
      - 2) Complete catalog information, descriptive literature, specifications, and materials of construction.
      - 3) Detailed structural and mechanical drawings showing the equipment dimensions, size, and installation.
      - 4) Process data and design calculations including flow rates and pressure loss.
      - 5) Factory protective coatings.
      - 6) Anchor bolt calculations and mounting details for each equipment assembly as specified in Sections 01612 - Seismic Design Criteria and 15050 - Common Work Results for Mechanical Equipment.
      - 7) Details of storage and off loading requirements.
      - 8) Sample warranty.
- B. Quality control submittals:
  - 1. Factory functional test report.
  - 2. Field performance test report.
  - 3. Certificate of Compliance with ASME Code Section VIII, Division 1.
  - 4. Certificates of Installation as specified in Section 01756 - Commissioning.
- C. Certificates as specified in Sections 01756 - Commissioning, 15050 - Common Work Results for Mechanical Equipment, and 15958 - Mechanical Equipment Testing.
- D. Warranties.

## **1.05 QUALITY ASSURANCE**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

## **1.06 DELIVERY, STORAGE AND HANDLING**

- A. As specified in Sections 01600 - Product Requirements and 15050 - Common Work Results for Mechanical Equipment.

## **1.07 PROJECT CONDITIONS**

- A. Environmental requirements: As specified in Section 15050 - Common Work Results for Mechanical Equipment.



## **1.08 SEQUENCING AND SCHEDULING**

- A. Coordinate work with restrictions as specified in Section 01140 - Work Restrictions.

## **1.09 WARRANTY**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment unless noted otherwise.
- B. Warrant equipment free of defects in material and workmanship for 2 years from the date of acceptance or date of first beneficial use of the equipment by the Owner, whichever is later.
  - 1. Warranty shall cover parts and labor.
- C. Manufacturer's warranty shall be issued in the Owner's name.

## **1.10 MAINTENANCE**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.
- B. Special tools:
  - 1. Provide the following:
    - a. One calibration meter suitable for use with all balancing valves and pump discharge valves (separate meter for each is required if single unit is not compatible with both).
  - 2. If special tools are required for the service and maintenance of any system components, provide 1 complete set of tools of each type and size required.
- C. Spare parts: Deliver the following as specified in Section 01600 - Product Requirements:
  - 1. One filter element for each filter regulator associated with a 3-way control valve actuator.
- D. Contractor, inspector, and Owner's maintenance representative shall inventory and account for all tools and spare parts delivered to the site.
  - 1. Each party shall sign a turn over agreement.
  - 2. Owner will then take possession and responsibility for items.

## **PART 2 PRODUCTS**

### **2.01 PUMP DISCHARGE VALVE**

- A. Manufacturers: One of the following or equal:
  - 1. Armstrong Flo-Trex.
  - 2. Bell & Gossett Division of ITT Corp., Triple Duty.
  - 3. Mueller Steam Specialty Control Chek.
  - 4. Taco Plus Two Multi-Purpose.
- B. Materials:
  - 1. Body: Cast iron or ductile iron.
  - 2. Disc: Bronze.
  - 3. Seat: Bronze.



4. Stem: Stainless steel.
  5. Spring: Stainless steel.
- C. Features:
1. Shall be a combination non-slam check valve, throttling valve, and isolation valve.
  2. External, calibrated adjustment indicator, and an adjustable memory stop.
  3. Straight pattern or angle pattern as specified or shown.
  4. ANSI standard flange connections unless otherwise specified.
  5. Rated for maximum working pressure of 175 pounds per square inch gauge.
  6. Rated for maximum operating temperature of 250 degrees Fahrenheit.
  7. Valves used in grooved-end piping systems shall have grooved-end type connections if indicated on the Drawings.
  8. Grooved-end connections shall be suitable for use with grooved-end couplings.

## **2.02 PUMP SUCTION DIFFUSER**

- A. Manufacturers: One of the following or equal:
1. Armstrong.
  2. Bell & Gossett Division of ITT Corp.
  3. Paco.
  4. Taco.
- B. Materials:
1. Body: Cast iron or ductile iron.
  2. Cover: Cast iron or ductile iron.
  3. Straightening vanes: Steel.
  4. Orifice cylinder: Steel.
  5. Start-up strainer: Brass or bronze.
- C. Features:
1. Shall be a combination strainer and pressure gradient equalizer.
  2. Suction diffuser inlet connection shall be an integral ANSI standard flange unless otherwise specified or shown.
  3. The suction diffuser inlet connection for grooved-end piping systems shall be grooved-end type, suitable for use with grooved-end couplings.
  4. Inlet size shall be the full line size of the connected pipe.
  5. Outlet size shall be equal to the connected pump's suction inlet size.
  6. Outlet connection shall be integral ANSI standard flange or female threaded outlet connection to match the pump suction inlet.
  7. Rated for maximum working pressure of 175 pounds per square inch gauge.
  8. The suction diffuser shall consist of an angle type body with inlet vanes and a combination diffuser-strainer orifice with 3/16-inch diameter openings.
  9. The unit shall be equipped with a disposable fine mesh start-up strainer, which shall be removed after system start-up.
  10. A flanged and bolted cover shall be provided to allow removal of the strainer without disturbing the piping system connections.
  11. A strainer blowdown opening and plug shall be provided in the suction diffuser body or cover.
  12. The unit shall be provided with an adjustable support foot.



## 2.03 THREE-WAY TEMPERATURE CONTROL VALVES

### A. Valves 6 inches and smaller:

1. Valve:
  - a. Manufacturers: One of the following or equal:
    - 1) Fisher Division of Emerson Process Management, "YS" type design with an electric actuator to suit configuration.
    - 2) Koso Hammel Dahl Division of Koso America, Inc., Series V830, equivalent models.
  - b. Materials:
    - 1) Body, bonnet, and bottom flange: Cast iron.
    - 2) Trim: Type 316 stainless steel.
    - 3) Packing: Teflon V-ring.
  - c. Features:
    - 1) Suitable for operation in response to a proportional 4-20 mA signal transmitted by electronic temperature controllers as indicated on the Drawings and specified in Sections 17100 - Control Strategies and 17101 - Specific Control Strategies.
    - 2) Suitable for service under pressures equal to and less than 125 pounds per square inch gauge, and under a maximum temperature of 220 degrees Fahrenheit.
    - 3) Plug: For open-close or throttling service with a V-port.
2. Electric operator:
  - a. Manufacturers: The following or equal:
    - 1) Rotork IQML.
  - b. Design:
    - 1) As specified in Section 13447 - Electric Motor Actuators.
  - c. Materials:
    - 1) As specified in Section 13447 - Electric Motor Actuators.
  - d. Operator accessories:
    - 1) As specified in Section 13447 - Electric Motor Actuators.
3. Valve sizing:
  - a.  $C_v$  values listed by manufacturer shall be determined in accordance with ISA 75.02.01.
  - b. Control valves shall be selected such that the valve with the  $C_v$  closest to that shown in the valve schedule that provides the best control under the specified pressures and flow rates will be utilized.
  - c. In general, valves for open-close operation shall be line size and valves for modulating operation shall be smaller than line size.
  - d. Contractor to provide reducers where the specific valve is smaller than the connected pipes.
4. 3-Way Temperature Control Valve Schedule:

Control Valve Tag Number	Control Valve Service	Pipe Size, Inches	$C_v$	Flow Direction Used for $C_v$ Determination	Flow, Gallons per Minute	Duty	Failure Position	Flow Type
FCV-214	FOG Hot Water Loop	4	134	All Flow from Side to Side	300	Modulating	Plug Up	Converging, common port on side



04

## **AUTOMATIC AIR VENTS, HOT WATER SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Bell & Gossett Division of ITT Corp., Number 87.
  - 2. Hoffman Specialty Manufacturing Corp., Number 78.
- B. Materials:
  - 1. Body: Brass with non-ferrous internals.
- C. Features:
  - 1. Provided for automatic removal of air entrained within a closed hot water system.
  - 2. Rated for maximum working pressure of 150 pounds per square inch gauge.
  - 3. Rated for maximum operating temperature of 240 degrees Fahrenheit.
  - 4. Vents shall be float-type.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine and verify that Work is in condition to receive installation specified in this Section:
  - 1. Take measurements and verify dimensions to ascertain fit of installation.
  - 2. Ascertain structural sufficiency to support installation.
  - 3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required:
    - a. Submit details of proposed cutting and patching.
  - 4. Confirm specified thermostat or other controls are compatible with specified equipment.
- B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.

### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's installation instructions and as specified in Section 15050 - Common Work Results for Mechanical Equipment.
- B. Provide venting and drains complying with the building code as specified in Section 01410 - Regulatory Requirements, and in accordance with NFPA 54, and NFPA 90A.
- C. Pump suction diffuser:
  - 1. The Contractor shall install suction diffuser on the suction connection of each pump where specified.
    - a. The adjustable support foot shall be mounted on the pump base and adjusted to support the suction diffuser.
    - b. The start-up strainer shall be removed after system start-up is complete.





- D. Circuit balancing valves:
  - 1. Circuit balancing valves shall be installed with at least the minimum length, recommended by the manufacturer, of straight unrestricted pipe upstream and downstream of the specified valve location.

### **3.03 FIELD FINISHING**

- A. Field coat as specified in Section 09960 - High-Performance Coatings.
- B. Air separators, pump discharge valves, suction diffusers, and balancing valves shall be insulated as specified in Section 15082 - Piping Insulation.

### **3.04 FIELD QUALITY CONTROL**

- A. Balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.
- B. Performance and function testing:
  - 1. As specified in Section 01756 - Commissioning.
- C. Certificate of installation:
  - 1. As specified in Section 01756 - Commissioning.

### **3.05 MANUFACTURER'S SERVICES**

- A. Provide training of the Owner's personnel as specified in Section 01756 - Commissioning:
  - 1. Require manufacturer's representative to perform the following services as described below and as specified in Section 01756 - Commissioning. The specified durations are the minimum required time on the job site. Additional services and/or longer durations shall be provided as needed at no cost to the Owner to meet the required quality of work:
    - a. Installation assistance:
      - 1) Check and verify that installation of the electro-pneumatic operators is as indicated on the Drawings and manufacturer's installation instructions.
      - 2) Provide additional assistance as required.
    - b. Installation inspection: 1 trip. One workday each trip for each type of valve and hot water system component.
    - c. Start-up/testing assistance: 1 trip. 2 workdays each trip for each type of valve and hot water system component.
    - d. Training: As specified in Section 01756 - Commissioning. Provide training as follows:
      - 1) Operations training: 2 hours of training, presented twice, for a total of 4 hours.
      - 2) Mechanical maintenance training: 4 hours of training, presented twice, for a total of 8 hours.
      - 3) Electrical maintenance training: 2 hours of training, presented twice, for a total of 4 hours.
    - e. Final acceptance checkout: 1 Workday each trip for each type of valve and hot water system component.
    - f. Post start-up checkout: 1 Workday each trip for each type of valve and hot water system component.



- B. Provide field performance testing and Certificate of Installation.

### **3.06 START-UP PROCEDURES**

- A. Perform start-up and testing as specified in Section 01756 - Commissioning.
- B. During start-up and testing, remove and clean the strainers at the air separator and suction diffusers after 24 hours and again after 30 days of hot water system operation.

END OF SECTION



## SECTION 15956

### PIPING SYSTEMS TESTING - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Test requirements for piping systems.

##### 1.02 REFERENCES

- A. National Fuel Gas Code (NFGC).
- B. American Society of Mechanical Engineers (ASME):
  - 1. B31.1 - Power Piping.
  - 2. B31.3 - Process Piping.
  - 3. B31.8 - Gas Transmission and Distribution Piping Systems.
- C. Underwriters Laboratories Inc. (UL).

##### 1.03 TESTING REQUIREMENTS

- A. General requirements:
  - 1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
  - 2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
  - 3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01410 - Regulatory Requirements, and UL requirements.
  - 4. Test natural gas or digester gas piping:
    - a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
    - b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
  - 5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
    - a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.
- B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.



- C. Water for testing, cleaning, and disinfecting:
  - 1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500 - Temporary Facilities and Controls.
- D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.
- E. Unsuccessful tests:
  - 1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
  - 2. Repeat testing until tests are successful.
- F. Test completion: Drain and leave piping clean after successful testing.
- G. Test water disposal: Dispose of testing water at the Fourche Creek WRF in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

#### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Schedule and notification of tests:
  - 1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
  - 2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
  - 3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

#### **1.05 SEQUENCE**

- A. Clean piping before pressure or leak tests.
- B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.
- C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.
- D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.
- E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.



## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION**

- A. Alignment and grade:
  - 1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
  - 2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.
- B. Deflection test:
  - 1. Pull a mandrel through the clean piping section under test.
  - 2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
  - 3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
  - 4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

### **3.02 AIR TESTING METHOD FOR PRESSURE PIPING**

- A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.
- B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
  - 1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.
- C. Test at pressure as specified in Piping Schedule in Section 15052 - Common Work Results for General Piping:
  - 1. Provide temporary pressure relief valve for piping under test:
    - a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
  - 2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASME B31.8, or the pipe manufacturer's stated maximum working pressure.
  - 3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
  - 4. Perform initial check of joints and fittings for leakage.
  - 5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage; at each step increase until test pressure reached.
  - 6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
  - 7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.



3.03

### TESTING GRAVITY FLOW PIPING

- A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
  - 1. Unless specified otherwise, subject gravity flow piping to the following tests:
    - a. Alignment and grade.
    - b. For plastic piping test for deflection.
    - c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
  - 2. Inspect piping for visible leaks before backfilling.
  - 3. Provide temporary restraints when needed to prevent movement of piping.
  - 4. Pressure test piping with maximum leakage allowance after backfilling.
  - 5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
    - a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
    - b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
    - c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
      - 1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
        - a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
          - (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
        - b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
        - c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

### 3.04 TESTING HIGH-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.
- B. General:
  - 1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
  - 2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
  - 3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.



4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
  5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
  6. When test results indicate failure of selected sections, limit tests to piping:
    - a. Between valves.
    - b. Between a valve and the end of the piping.
    - c. Less than 500 feet long.
  7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Testing procedures:
1. Fill piping section under test slowly with water while venting air:
    - a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
  2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
  3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
    - a. Consider visible leakage testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
  2. Pressure test piping after completion of visible leaks test.
  3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
    - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
    - b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.





- c. When leakage is allowed, calculate the allowable leakage by the following formula:

$$L = S \times D \times P^{1/2} \times 133,200^{-1}$$

wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

### 3.05 TESTING LOW-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.
- B. General:
1. Test pressures shall be as scheduled in Section 15052 - Common Work Results for General Piping.
  2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
  3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
  4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Visible leaks test:
1. Subject piping under test to specified pressure measured at the lowest end.
  2. Fill piping section under test slowly with water while venting air:
    - a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
  3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
  4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
1. Pressure test piping after completion of visible leaks test.



2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
  - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
  - b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:

1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
  - a. Joint testing will be allowed only for low head pressure piping.
  - b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint testing with water:
  - a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
  - b. Maintain test pressure for 1 minute.
  - c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
  - d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
  - e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint testing with air:
  - a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
  - b. Maintain test pressure for 2 minutes.
  - c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION





## SECTION 15958

### MECHANICAL EQUIPMENT TESTING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Testing of mechanical equipment and systems.

##### 1.02 REFERENCES

- A. American National Standards Institute (ANSI):
  - 1. S1.4 Specification for Sound Level Meters.
- B. Hydraulic Institute (HI).
- C. National Institute of Standards and Technology (NIST).

##### 1.03 SUBMITTALS

- A. Project closeout documents:
  - 1. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.
    - a. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

#### PART 2 PRODUCTS

Not Used.

#### PART 3 EXECUTION

##### 3.01 GENERAL

- A. Commissioning of equipment as specified in:
  - 1. This Section.
  - 2. Section 01756 - Commissioning.
  - 3. Equipment sections:
    - a. If testing requirements are not specified, provide Level 1 Tests.
- B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.
- C. Operation of related existing equipment:
  - 1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.
  - 2. Schedule and coordinate testing as required by Section 01756 - Commissioning.



- D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
  - 1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
  - 2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.
- E. Test measurement and result accuracy:
  - 1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
    - a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
  - 2. Do not adjust results of tests for instrumentation accuracy.
    - a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

### **3.02 VARIABLE SPEED EQUIPMENT TESTS**

- A. Establish performance over the entire speed range and at the average operating condition.
- B. Establish performance curves for the following speeds:
  - 1. The speed corresponding to the rated maximum capacity.
  - 2. The speed corresponding to the minimum capacity.
  - 3. The speed corresponding to the average operating conditions.

### **3.03 PUMP TESTS, ALL LEVELS OF TESTING**

- A. Test in accordance with the following:
  - 1. Applicable HI Standards.
  - 2. This Section.
  - 3. Equipment sections.
- B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
  - 1. From 0 to plus 5 percent of head at the specified flows.
  - 2. From 0 to plus 5 percent of flow at the rated design point head.
  - 3. No negative tolerance for the efficiency at the specified flows
  - 4. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

### **3.04 DRIVERS TESTS**

- A. Test motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
- B. Test other drivers as specified in the equipment section.



### **3.05 NOISE REQUIREMENTS AND CONTROL**

- A. Perform noise tests in conjunction with vibration test analysis.
- B. Make measurements in relation to reference pressure of 0.0002 microbar.
- C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
- D. Set sound level meter to slow response.
- E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

### **3.06 PRESSURE TESTING**

- A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

### **3.07 INSPECTION AND BALANCING**

- A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.
- B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
- C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.
- D. Critical speed of rotating equipment:
  - 1. Satisfy the following:
    - a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
    - b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
    - c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.
- E. Vibration tests:
  - 1. Definitions:
    - a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
    - b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.



- c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
- d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
- e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
  - 1) Manufacturers: One of the following or equal:
    - a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
    - b) CSI, "PeakVue."
- f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
- g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
- h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
- i. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
- j. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.
- 2. Vibration instrumentation requirements:
  - a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
    - 1) Manufacturers: One of the following or equal:
      - a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
      - b) Pruftechnik, VIBXPERT II.
  - b. Analyzer settings:
    - 1) Units: English, inches/second, mils, and gravitational forces.
    - 2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
    - 3) Sample averages: 4 minimum.
    - 4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
    - 5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
    - 6) Fast fourier transform windowing: Hanning Window.
    - 7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.





- c. Accelerometers:
  - 1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
    - a) Manufacturers: One of the following or equal:
      - (1) Wilcoxon Research, Model 797L.
      - (2) PCB, Model 393C.
  - 2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
    - a) Manufacturers: One of the following or equal:
      - (1) Wilcoxon Research, Model 793.
      - (2) Entek-IRD Model 943.
- 3. Accelerometer mounting:
  - a. Use magnetic mounting or stud mounting.
  - b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
  - c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
- 4. Vibration acceptance criteria:
  - a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
  - b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

- c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:



HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) Vertical Solids Handling Centrifugal Pumps	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

- d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.
- e. Additional criteria:
  - 1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.



- 2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
- 3) For motors, the following shall be cause for rejection:
  - a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
  - b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
  - c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
  - d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
- 4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.
5. Vibration testing results presentation:
  - a. Provide equipment drawing with location and orientation of measurement points indicated.
  - b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
  - c. When Vibration Spectra Data required:
    - 1) Plot peak vibration velocity versus frequency in cycles per minute.
    - 2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
    - 3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
    - 4) Plot motor spectra on a log amplitude scale versus frequency.
  - d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
  - e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

### **3.08 TESTING LEVELS**

- A. Level 1 Tests:
  1. Level 1 General Equipment Performance Test:



- a. For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
    - b. Operate at rated design load conditions.
    - c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
  2. Level 1 Pump Performance Test:
    - a. Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
    - b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower or the applicable equipment section. Use actual driver for field tests.
    - c. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
  3. Level 1 Vibration Test:
    - a. Test requirement:
      - 1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
      - 2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
    - b. Equipment operating condition: Test at specified maximum speed.
  4. Level 1 Noise Test:
    - a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.
- B. Level 2 Tests:
1. Level 2 General Performance Test:
    - a. For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
    - b. Operate at rated design load conditions.
    - c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
  2. Level 2 Pump Performance Test:
    - a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.



- b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
  - c. Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
  - d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
3. Level 2 Vibration Test:
- a. Test requirement:
    - 1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
    - 2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
  - b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
  - c. Natural frequency test of field installed equipment:
    - 1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
    - 2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
    - 3) Perform with equipment and attached piping full of intended service or process fluid.
4. Level 2 Noise Test:
- a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:

- 1. Level 3 General Equipment Performance Tests:
  - a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
  - b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
  - c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
  - d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.



- e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
- 2. Level 3 Pump Performance Test:
  - a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
  - b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
  - c. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
  - d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
- 3. Level 3 Vibration Test:
  - a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
  - b. Perform High Frequency Enveloping Analysis for gears and bearings.
    - 1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
    - 2) Report results in units of acceleration versus frequency in cycles per minute.
  - c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
  - d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
- 4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.
- D. Level 4 Tests:
  - 1. Level 4 General Equipment Performance Test:
    - a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
    - b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.





- c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
  - d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
  - e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
2. Level 4 Pump Performance Test:
- a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
  - b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
  - c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
  - d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
  - e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
    - 1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
    - 2) Perform efficiency testing with test fluids at maximum rated speed.
    - 3) Perform priming time testing with test fluids at maximum rated speed.
3. Level 4 Vibration Test: Same as Level 3 vibration test.
4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION







## SECTION 16050

### COMMON WORK RESULTS FOR ELECTRICAL

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. General requirements applicable to all Electrical Work.
  - 2. General requirements for electrical submittals.
- B. Interfaces to equipment, instruments, and other components:
  - 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
  - 2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
    - a. Make all changes necessary to meet the manufacturer's wiring requirements.
  - 3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700 - General Conditions.
  - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
    - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
  - 5. Loop drawings:
    - a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
      - 1) Conduit numbers and associated signal(s) contained within each conduit.
      - 2) Wire numbers.
      - 3) Equipment terminal numbers.
      - 4) Junction boxes and signal(s) contained within each junction box.
      - 5) Equipment power sources, and associated circuit numbers.
      - 6) As-built drawings detailing wiring.
- C. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
  - 1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
  - 2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.



3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.
- D. Contract Documents:
1. General:
    - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
  2. Specifications:
    - a. The General and Supplementary Conditions of the Contract Documents govern the Work.
    - b. These requirements are in addition to all General Requirements.
  3. Contract Drawings:
    - a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
    - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
      - 1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
      - 2) The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
    - c. Installation details:
      - 1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      - 2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
    - d. Schematic diagrams:
      - 1) All controls are shown de-energized.
      - 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
      - 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      - 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.



- 5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:

1. Coordinate with Document 00700 - General Conditions for substitute item provisions.

F. Changes and change orders:

1. As specified in Document 00700 - General Conditions.

## 1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01410 - Regulatory Requirements.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this Section.
  - a. American National Standards Institute (ANSI).
  - b. American Society of Civil Engineers (ASCE):
    - 1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
  - c. ASTM International (ASTM).
  - d. Illuminating Engineering Society (IES).
  - e. Institute of Electrical and Electronics Engineers (IEEE).
  - f. Insulated Cable Engineers Association (ICEA).
  - g. International Code Council (ICC):
    - 1) International Code Council Evaluation Service (ICC-ES).
      - a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
  - h. International Society of Automation (ISA).
  - i. National Electrical Manufacturers Association (NEMA):
    - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
  - j. National Fire Protection Association (NFPA):
    - 1) 70 - National Electrical Code (NEC).
  - k. National Institute of Standards and Technology (NIST).
  - l. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:

1. As specified in Document 00700 - General Conditions.

## 1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.



8. NIST.

B. Specific definitions:

1. FAT: Factory acceptance test.
2. LCS: Local Control Station
3. ICSC: Instrumentation and controls subcontractor.
4. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
5. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
6. PCIS: Process control and instrumentation system.
7. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
8. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
9. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
10. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
11. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

#### 1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
  - a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any



change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.

5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
  - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
  - b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
6. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
  - a. As specified in the Contract Documents.
7. Defective work:
  - a. As specified in Document 00700 - General Conditions.

**B. Operating facility:**

1. As specified in Section 01140 - Work Restrictions.
2. The Fourche Water Reclamation Facility is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
  - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
  - b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
  - c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

## **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.
- B. General:
  1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
  2. Furnish the submittals required by each section in the Electrical Specifications.
  3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
    - a. Uniquely number each wire.



- b. Wire numbers must appear on all Equipment Drawings.
      4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
    - C. Seismic requirements:
      1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01612 - Seismic Design Criteria.
      2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
        - a. Statement of seismic qualification, and special seismic certification:
          - 1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410 - Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
          - 2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with  $I_p = 1.5$ ." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
        - b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
        - c. Anchoring design calculations and details:
          - 1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612 - Seismic Design Criteria.
      3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
        - a. Temporary or moveable equipment.
        - b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
        - c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.
    - D. Submittal organization:
      1. First page:
        - a. Specification section reference.
        - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
        - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
        - d. Place for Contractor's review stamp and comments.
      2. Next pages:
        - a. Provide confirmation of specification compliance:





- 1) Specification section: Include with each submittal a copy of the relevant specification section.
  - a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
  - b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
- b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
  - 1) In the order that the comments or questions were presented throughout the submittal.
  - 2) Referenced by index section and page number on which the comment appeared.
  - 3) Acceptable responses to Engineer's comments are either:
    - a) Engineer's comment or change is accepted and appropriate changes are made.
    - b) Explain why comment is not accepted or requested change is not made.
    - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
  - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
  - 5) No further review by the Engineer will be performed until a response for previous comments has been received.
3. Remaining pages:
  - a. Actual submittal data:
    - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
    - 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
  - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submit copies of shop drawings, and product data:
  - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:



- a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:
  - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
  - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
  - c. Acceptance of any exception is at the sole discretion of the Engineer.
    - 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
  - d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
7. Specific submittal requirements:
  - a. Shop drawings:
    - 1) Required for materials and equipment listed in this and other sections.
    - 2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
    - 3) Shop drawings requirements:
      - a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
      - b) Locations of conduit entrances and access plates.
      - c) Component layout and identification.
      - d) Schematic and wiring diagrams with wire numbers and terminal identification.
      - e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
      - f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
      - g) Weight.
      - h) Finish.
      - i) Nameplates:
        - (1) As specified in Section 16075 - Identification for Electrical Systems.
      - j) Temperature limitations, as applicable.
  - b. Product data:
    - 1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
    - 2) Include:
      - a) Catalog cuts.
      - b) Bulletins.
      - c) Brochures.
      - d) Quality photocopies of applicable pages from these documents.



- e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
    - f) Identify model number and options for the actual equipment being furnished.
    - g) Neatly cross out options that do not apply or equipment not intended to be supplied.
  - c. Detailed sequence of operation for all equipment or systems.
- F. Operation and maintenance manuals:
  - 1. As specified in Section 01782 - Operation and Maintenance Data.
  - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.
- G. Material and equipment schedules:
  - 1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
    - a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- H. Schedule of values:
  - 1. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
- I. Roof penetrations:
  - 1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.
- J. Record Documents:
  - 1. Furnish as specified in Section 01770 - Closeout Procedures.
  - 2. Provide Record Documents of all Electrical Drawings.
  - 3. Record Drawing requirements:
    - a. Update Record Drawings weekly.
    - b. Record Drawings must be fully updated as a condition of the monthly progress payments.
    - c. Submit Record Drawings upon completion of the Work for final review.
    - d. Clearly and neatly show all changes including the following:
      - 1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
  - 4. Shop drawings:
    - a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
      - 1) Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch paper.



- a) Size all drawings to be readable and legible on 11-17 inch media.
  - 2) Provide electronic copies of these documents on CD-ROM or DVD disks in PDF format.
- 5. Review and corrections:
  - a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
  - b. Promptly correct and re-submit record documents returned for correction.
- K. Test reports:
  - 1. As specified in Section 01330 - Submittal Procedures.
  - 2. Include the following:
    - a. A description of the test.
    - b. List of equipment used.
    - c. Name of the person conducting the test.
    - d. Date and time the test was conducted.
    - e. All raw data collected.
    - f. Calculated results.
    - g. Each report signed by the person responsible for the test.
  - 3. Additional requirements for field acceptance test reports are specified in Sections 01756 - Commissioning and 16950 - Field Electrical Acceptance Tests.
- L. Calculations:
  - 1. Where required by specific Electrical Specifications:
    - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

## **1.06 QUALITY ASSURANCE**

- A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 01600 - Product Requirements.
- B. Shipping precautions:
  - 1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
  - 2. Place dehumidifiers, when required, inside the polyethylene coverings.
  - 3. Skid-mount the equipment for final transport.
  - 4. Provide lifting rings for moving without removing protective covering.
  - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- C. Delivery and inspection:
  - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.



- D. Special instructions:
1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

## 1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
  2. Seismic load resistance:
    - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612 - Seismic Design Criteria.
  3. Wind load resistance:
    - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01614 - Wind Design Criteria.
  4. Altitude, temperature and humidity:
    - a. As specified in Section 01610 - Project Design Criteria.
    - b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
    - c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
      - 1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
  5. Outdoor installations:
    - a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
    - b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
      - 1) Provide all wiring necessary to power these devices.
- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
  2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
  3. NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and



freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.

4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
5. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052 - Hazardous Classified Area Construction.

C. Plant area Electrical Work requirements:

1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Indoor Conditioned Spaces	NEMA 12	Galvanized rigid steel	C	Stainless steel
Outdoor	NEMA 3R	Galvanized rigid steel	W	Stainless steel
Digester Complex Interior	NEMA Type 7	PVC coated galvanized rigid steel	H	Stainless steel
FOG Station	NEMA 4X	Galvanized rigid steel	X	Stainless steel

2. Modify exposed conduit runs as specified in Section 16130 - Conduits.

## 1.09 SEQUENCING (NOT USED)

## 1.10 SCHEDULING

A. General:

1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
2. Testing requirements are specified in Section 01756 - Commissioning, 16950 - Field Electrical Acceptance Tests and other sections.
3. General scheduling requirements are specified in Section 1321 – Schedules and Reports.
4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
5. Commissioning requirements as specified in Section 01756 - Commissioning.

B. Pre-submittal conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.





2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.
- C. Factory acceptance testing (FAT):
  1. Where FAT is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
    - a. Indicate the desired dates for inspection and testing.
    - b. Schedule the FAT after approval of the FAT procedures submittal:
      - 1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
      - 2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

### **1.11 WARRANTY**

- A. Warrant the Electrical Work as specified in Document 00700 - General Conditions:
  1. Provide additional warranty as specified in the individual Electrical Specifications.

### **1.12 SYSTEM START-UP**

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
  1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

### **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

### **1.14 MAINTENANCE**

- A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by other sections of the Specifications.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.
- B. Allowable manufacturers are specified in individual Electrical Specifications.

### **2.02 EXISTING PRODUCTS (NOT USED)**





### **.03 MATERIALS**

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in Document 00700 - General Conditions.
- C. Stainless steel:
  - 1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
  - 2. Provide exposed screws of the same alloys.
  - 3. Provide finished material free of any burrs or sharp edges.
  - 4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
  - 5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
  - 6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

#### **2.04 MANUFACTURED UNITS (NOT USED)**

#### **2.05 EQUIPMENT (NOT USED)**

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES (NOT USED)**

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES (NOT USED)**

#### **2.11 SOURCE QUALITY CONTROL**

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.
- B. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.



- C. Comply with pre-bid conference requirements as specified in Document 00200 - Instructions to Bidders.
- D. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
  - 1. Verify all dimensions indicated on the Drawings:
    - a. Actual field conditions govern all final installed locations, distances, and levels.
  - 2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
  - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
  - 4. Provide a complete electrical system:
    - a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. Cutting and patching:
  - 1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
    - a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
      - 1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
        - a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
        - b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
    - b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
  - 2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
    - a. 3M: CP 25WB+: Caulk.
    - b. 3M: Fire Barrier: Putty.
  - 3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.



- D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
  - 1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
    - a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
  - 2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
    - a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
  - 3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
  - 4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
- E. Earthwork and concrete:
  - 1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
    - a. Requirements as specified in the Contract Documents.
- F. Roof penetrations:
  - 1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.
- G. Terminations:
  - 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.
- H. Miscellaneous installation requirements:
  - 1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 00700 - General Conditions.
  - 2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
  - 3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
  - 4. Circuits of different service voltage:
    - a. Voltage and service levels:
      - 1) Medium voltage: greater than 1.0 kV.
      - 2) Low voltage: 120 V to 480 V.
      - 3) Instrumentation: Less than 50 VDC.
    - b. Install different service voltage circuits in separate raceways, and junction boxes.
    - c. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.
- I. Labeling:



- J. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
    - a. All control panels must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. For Owner and Engineer witnessed FAT:
1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01756 - Commissioning.
- C. Owner training:
1. As specified in Section 01756 - Commissioning and in this Section.
  2. Provide source testing and owner training on electrical equipment as defined in the table below:

Table1: Source Testing and Owner Training Requirements:

Section Number	Section Title	Source Testing (Witnessed or Non-witnessed)	Owner Training Requirements	
			Maintenance (hrs per session)	Operation (hrs per session)
16262	Variable Frequency Drives 0.50 - 50 Horsepower	Witnessed	8	8
16422	Motor Starters	Non-Witnessed	8	8
16444	Low Voltage Motor Control Centers	Witnessed	N/A	N/A

### **3.08 FIELD QUALITY CONTROL**

- A. Inspection:
1. Allow for inspection of electrical system installation as specified in Section 01450 - Quality Control.
  2. Provide any assistance necessary to support inspection activities.
  3. Engineer inspections may include, but are not limited to, the following:
    - a. Inspect equipment and materials for physical damage.
    - b. Inspect installation for compliance with the Drawings and Specifications.
    - c. Inspect installation for obstructions and adequate clearances around equipment.
    - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.



- e. Inspect equipment nameplate data to verify compliance with design requirements.
    - f. Inspect raceway installation for quality workmanship and adequate support.
    - g. Inspect cable terminations.
  - 4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.
- B. Field acceptance testing (Functional Testing):
  - 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
  - 2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
  - 3. Record results of the required tests along with the date of test:
    - a. Use conduit identification numbers to indicate portion of circuit tested.
- C. Workmanship:
  - 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
    - a. Neatly coil and label spare wiring lengths.
    - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

### **3.09 ADJUSTING (NOT USED)**

### **3.10 CLEANING**

- A. As specified in Section 01770 - Closeout Procedures.
- B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.
- C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
  - 1. Use of compressors or air blowers for cleaning is not acceptable.
- D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction, and return all used lamps to the Owner.
- E. As specified in other sections of the Contract Documents.

### **3.11 PROTECTION**

- A. Protect all Work from damage or degradation until Substantial Completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16052

### HAZARDOUS CLASSIFIED AREA CONSTRUCTION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and as indicated on the Drawings and specified in the Specifications.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
  - 1. For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

##### 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
  - 1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
  - 2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
  - 3. All devices used in Class I Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.

##### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.08 PROJECT OR SITE CONDITIONS**

- A. The following areas are classified Class I, Division 1:
  - 1. Digester Complex interior.

## **1.09 SEQUENCING**

- A. Conduit seals shall be filled during start-up and commissioning after verification of field wiring. Conduit seals shall be filled prior to the introduction of process or gas to the equipment/area.

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY (NOT USED)**

## **1.12 SYSTEM START-UP (NOT USED)**

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS (NOT USED)**

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS**

- A. Conduit and sealing fittings:
  - 1. As specified in Section 16130 - Conduits.
- B. Conduit boxes and bodies:
  - 1. As specified in Section 16134 - Boxes.
- C. Wiring devices:
  - 1. As specified in Section 16140 - Wiring Devices.

## **2.07 ACCESSORIES (NOT USED)**

## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES (NOT USED)**





## **2.11 SOURCE QUALITY CONTROL (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Conduit installation:
  - 1. As specified in Section 16130 - Conduits.
  - 2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.
  - 3. Make all conduit connections so that there are a minimum of 5 threads fully engaged in the connection.
  - 4. Flexible conduit:
    - a. Class I Division 1 hazardous areas:
      - 1) Approved and marked suitable for Class I Division 1.
      - 2) Listed for compatibility with the group type atmosphere where used.
    - b. Class I Division 2 areas:
      - 1) Liquidtight metal conduit with approved fittings.
    - c. Maximum length as specified in Section 16130 - Conduits.
- C. Sealing fittings:
  - 1. Provide an approved seal, no more than 12 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
    - a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies similar to "L", "T", and "X" may be installed between the sealing fitting and the enclosure.
  - 2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
    - a. Seals are required in all conduit connections to the compartment containing splices and must be within 12 inches of the enclosure.
  - 3. Install a conduit seal within 12 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
  - 4. For underground conduits entering or leaving a classified location or between Class I Division 1 and Division 2 locations:
    - a. Provide a conduit seal at both points where the conduit emerges from the ground:
      - 1) Place the conduit seal within 18 inches of finished grade.



- 2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.
  5. Separate all conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
    - a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.
  6. Install seals with drains in all electrical control stations, low points of conduit or any place where moisture may condense and accumulate.
  7. Install the sealing compound with a minimum thickness of 5/8 inch or the trade size of the conduit, whichever is greater.
- D. Boxes and fittings:
1. Class I Division 1 areas:
    - a. Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.
  2. Class I Division 2 areas:
    - a. Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.
- E. Outlet boxes and bodies:
1. Provide conduits bodies and boxes suitable for the conduit system as specified in Section 16130 - Conduits.
  2. Class I Division 2 areas:
    - a. Boxes not containing arcing parts:
      - 1) Material and NEMA ratings as specified in Section 16050 - Common Work Results for Electrical.
      - 2) Pressed metal boxes are not allowed.
    - b. Provide heavy duty cast construction type conduit fittings and joints:
      - 1) Explosion proof rated fittings and joints are not necessary.
    - c. Any enclosure containing arcing parts, etc. shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I Division 1 construction.
- F. Motor connections:
1. Conduit installation in Class I Division 1 and Class I Division 2 locations for motors that contain arcing parts, shall proceed as follows:
    - a. First - Conduit.
    - b. Second - Explosion proof flexible coupling.
    - c. Third - Sealing fitting.
    - d. Fourth - Explosion proof union.
    - e. Fifth - Connection to the motor terminal box.
  2. Wiring connections to motor leads shall be as specified in Section 16150 - Low Voltage Wire Connections.
  3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**



**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Obtain inspection and approval from the Engineer before and after each seal is poured.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION (NOT USED)**

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16060

### GROUNDING AND BONDING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Grounding materials and requirements.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
  - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- D. Underwriters Laboratories, Inc. (UL):
  - 1. 467 - Ground and Bonding Equipment.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Catalog cut sheets.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All grounding components and materials shall be UL listed and labeled.

##### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.



**1.07 PROJECT/SITE CONDITIONS (NOT USED)**

**1.08 SEQUENCING (NOT USED)**

**1.09 SCHEDULING (NOT USED)**

**1.10 WARRANTY**

A. As specified in Section 16050 - Common Work Results for Electrical.

**1.11 SYSTEM START-UP**

A. As specified in Section 16050 - Common Work Results for Electrical.

**1.12 OWNER'S INSTRUCTIONS (NOT USED)**

**1.13 MAINTENANCE (NOT USED)**

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

A. Exothermic connectors: One of the following or equal:

1. Erico.
2. Harger.
3. Burndy.
4. Thomas & Betts.

B. Ground rods: One of the following or equal:

1. Erico.
2. Harger.
3. Nehring
4. Thomas & Betts.

C. Ground cable: One of the following or equal:

1. Erico.
2. Harger
3. Nehring.
4. Southwire.

D. Precast ground well boxes: One of the following or equal:

1. Brooks Products, 3-RT Valve Box.
2. Christy Concrete Products, G12 Valve Box.

**2.02 SYSTEM DESCRIPTION**

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:

1. Grounding electrodes.



2. Bonding jumpers.
  3. Ground connections.
- C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
1. 5 ohms or less for industrial systems.

## **2.03 EXISTING PRODUCTS (NOT USED)**

## **2.04 MATERIALS**

- A. Ground rod:
1. Minimum: 3/4-inch diameter, 10 feet long.
  2. Uniform 10 mil covering of electrolytic copper metallurgically bonded to a rigid steel core:
    - a. The copper-to-steel bond shall be corrosion resistant.
  3. In accordance with UL 467.
  4. Sectional type joined by threaded copper alloy couplings.
  5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
1. Requirements:
    - a. Soft drawn (annealed).
    - b. Concentric lay, coarse stranded in accordance with ASTM B8.
  2. Size is as indicated on the Drawings, but not less than required by the NEC.
- C. Exothermic welds:
1. Current carrying capacity equal to that of the conductor.
  2. Permanent molecular bond that cannot loosen or corrode over time.
  3. Will not deteriorate with age.
  4. Use low emission welds for indoor installations.
- D. Equipment grounding conductors:
1. Conductors shall be the same type and insulation as the load circuit conductors:
    - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
  2. Minimum size in accordance with the NEC.
- E. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.
- F. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

## **2.05 MANUFACTURED UNITS (NOT USED)**

## **2.06 EQUIPMENT (NOT USED)**





## **2.07 COMPONENTS (NOT USED)**

### **2.08 ACCESSORIES**

- A. Precast ground well boxes:
  - 1. Minimum 10 inch interior diameter.
  - 2. Traffic-rated cast iron cover.
  - 3. Permanent "GROUND" marking on cover.

### **2.09 MIXES (NOT USED)**

### **2.10 FABRICATION (NOT USED)**

### **2.11 FINISHES (NOT USED)**

### **2.12 SOURCE QUALITY CONTROL (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
  - 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
  - 2. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
  - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
  - 1. Individually bond these raceways to the ground bus in the equipment.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.



- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- H. Duct bank ground system:
  - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
  - 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- I. Grounding at service (600 V or Less):
  - 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- J. Ground connections:
  - 1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
  - 2. Make ground connections in accordance with the manufacturer's instructions.
  - 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
- K. Grounding electrode system:
  - 1. Ground ring:
    - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
    - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
    - c. Minimum burial depth 36 inches or as indicated on the Drawings.
    - d. Re-compact disturbed soils to original density in 6-inch lifts.
  - 2. Ground rods:
    - a. Locations as indicated on the Drawings.
    - b. Length of rods forming an individual ground array shall be equal in length.
    - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
  - 3. Metal underground water pipe:
    - a. Bond metal underground domestic water pipe to grounding electrode system.
  - 4. Metal frame of building or structure:
    - a. Bond metal frame of building or structure to grounding electrode system.
  - 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
  - 6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.
  - 7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.



- L. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
  2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
  3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
  4. Terminate the signal cable shield on a dedicated grounding terminal block.

M. Where indicated on the Drawings, install ground rods in precast ground wells.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

#### **3.09 ADJUSTING**

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:

1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

#### **3.10 CLEANING (NOT USED)**

#### **3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

#### **3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16070

### HANGERS AND SUPPORTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Mounting and supporting electrical equipment and components.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Conform to the requirements of the Building Code as specified in Section 01410 - Regulatory Requirements.
  - 2. Demonstrate the following using generally accepted engineering methods:
    - a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
    - b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
  - 3. Design loading and anchoring requirements:
    - a. As indicated in the Building Code unless otherwise specified.
    - b. Seismic loading requirements:
      - 1) Freestanding, suspended or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050 - Common Work Results for Electrical.
    - c. Wind loading requirements:
      - 1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050 - Common Work Results for Electrical.
    - d. Minimum safety factor against overturning: 1.5.



- e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

B. Performance requirements:

- 1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

## 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:

- 1. Supports:
  - a. Materials.
  - b. Geometry.
  - c. Manufacturer.
- 2. Hardware:
  - a. Materials.
  - b. Manufacturer.

C. Shop drawings:

- 1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
- 2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, and wall supports for all equipment:
  - a. For free standing supports and wall supports supporting equipment weight in excess of 200 pounds:
    - 1) Stamped by a professional engineer licensed in the state where the Project is being constructed.
  - b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
- 3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation instructions:

- 1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
  - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

## 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM STARTUP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Preformed channel:
    - a. Thomas & Betts.
    - b. Power-Strut.
    - c. Unistrut.
    - d. Cooper B-Line.
    - e. Robroy.
    - f. Tyco.
- B. Nonmetallic cable rack:
  - 1. Underground Devices Inc.
  - 2. Hubbell.
  - 3. Unistrut.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.
- B. Preformed channel:
  - 1. Stainless steel:
    - a. Supports:
      - 1) In accordance with ASTM A240.
      - 2) ANSI Type 316 material.
    - b. Hardware:
      - 1) ANSI Type 316 material.



- C. Non-metallic cable rack:
1. Consists of stanchions and cable support arms.
  2. Stanchions:
    - a. 50 percent glass reinforced nylon or other non-metallic material.
    - b. Capable of supporting multiple arms.
    - c. Recessed bolt mounting holes.
    - d. Length as required.
  3. Arms:
    - a. 50 percent glass reinforced nylon or other non-metallic material.
    - b. Size the arms based on the length and weight of the cable to be supported.
  4. Stainless steel mounting hardware.

#### **2.04 MANUFACTURED UNITS (NOT USED)**

#### **2.05 EQUIPMENT (NOT USED)**

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES**

- A. Anchor bolts:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES**

- A. Paint and finish all supporting structures as specified in Section 09960 – High-Performance Coatings.

#### **2.11 SOURCE QUALITY CONTROL (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Preformed Channel:
1. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
    - a. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.





2. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
  - a. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
3. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
  - a. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
  - b. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
  - c. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
  - 1) Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
5. Corrosion protection:
  - a. Isolate dissimilar metals, except where required for electrical continuity.
    - 1) Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
6. Raceway:
  - a. Furnish all racks and trapeze structures needed to support the raceway from the structure.
    - 1) Group raceway and position on racks to minimize crossovers.
    - 2) Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
7. Anchoring methods:
  - a. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
  - b. Metal surfaces: Machine screws or bolts.
  - c. Hollow masonry units: Post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
8. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.
9. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

C. Non-metallic cable rack:

1. Install the non-metallic cable rack in accordance with the manufacturer's recommendations.
2. Provide at least 2 stanchions and 2 arms at each installation.
3. Mount the cable rack so that the supported cable does not interfere with access to manhole or handhole and so that the supported cable does not lie on the floor.
4. Do not exceed the cable manufacturer's minimum bending radius.
5. Use nylon cable ties to secure the cable to the supports.



**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16075

### IDENTIFICATION FOR ELECTRICAL SYSTEMS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Identification of electrical equipment, devices and components.
  - 2. Material, manufacturing and installation requirements for identification devices.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Occupational Safety and Health Administration (OSHA).

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SYSTEM DESCRIPTION

- A. Nameplates:
  - 1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
  - 2. Provide all nameplates of identical style, color, and material throughout the facility.
  - 3. Device nameplates information:
    - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
- B. Wire numbers:
  - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
    - a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
    - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
    - c. Internal panel wires on a common terminal shall have the same wire number.
    - d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
      - 1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130 - Conduits.



2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)-(ORIGIN TERM.)/(DEST. LOC.)-(DEST. TERM.)

OR

(ORIGIN LOC.)-(ORIGIN TERM.)  
(DEST. LOC.)-(DEST. TERM.)

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

I/O address at destination panel:

- a. Identify equipment and field instruments as the origin.
- b. PCMs are always identified as the destination.
- c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
- d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
- e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
- f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
  - 1) Discrete Point: W:X:Y/Z.  
Analog Point: W:X:Y.Z.  
Where:  
W= I for input, O for output  
X= PLC number (1, 2, 3...)  
Y= Slot number (01, 02, 03...)  
Z= Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
- g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).



3. **Case 1:** Vendor control panel (VCP) to process control module (PCM):  
Field wire number/label: A-B/C-D  
A = Vendor control panel number without hyphen (VCP#)  
B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)  
C = Process control module number without hyphen (PCM#)  
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I: 1:01/01  
VCP#-10/PCM#-O: 1:10/07  
VCP#-10/PCM#-C0100

4. **Case 2:** Field instrument to process control module (PCM):  
Field wire number/label: E-F/C-D  
C = Process control module number without hyphen (PCM#)  
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)  
E = Field mounted instrument tag and loop numbers without hyphen (EDV#)  
F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples: TIT#-2,3/PCM#-I: 1:01.1  
TSH#-1/PCM#-I: 2:01/00

5. **Case 3:** Motor control center (MCC) to process control module (PCM):  
Field wire number/label: G-B/C-D  
B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)  
C = Process control module without hyphen (PCM#)  
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)  
G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples: MMS#-10/PCM#-I: 1:01/01  
MMS#-10/PCM#-O: 1:10/07  
MMS#-10/PCM#-C0100

6. **Case 4:** Motor control center (MCC) to vendor control panel (VCP):  
Field wire number/label: G-B/A-B  
A = Vendor control panel number without hyphen (VCP#)  
B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)  
G = Actual starter designation in the motor control center without hyphen (MMS#)

Example: MMS#-X2/VCP#-10



7. **Case 5:** Motor leads to a motor control center (MCC):  
Field wire number/label: H-I/G-B  
B = Terminal number within motor control center (manufacturer's standard terminal number)  
G = Actual starter designation in the motor control center without hyphen (MMS#)  
H = Equipment tag and loop number without hyphen (PMP#)  
I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)

Example: PMP-#-T3/MMS#-T3

8. Identify all spare conductors as required for other field wires with an "S" prefix:

Example: S MMS#-10/PCM#-C011

### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
1. Nameplates:
    - a. Color.
    - b. Size:
      - 1) Outside dimensions.
      - 2) Lettering.
    - c. Material.
    - d. Mounting means.
  2. Nameplate schedule:
    - a. Show exact wording for each nameplate.
    - b. Include nameplate and letter sizes.
  3. Wire numbers:
    - a. Manufacturer's catalog data for wire labels and label printer.
- C. Record documents:
1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

### 1.06 QUALITY ASSURANCE (NOT USED)

### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

### 1.08 PROJECT SITE CONDITIONS (NOT USED)

### 1.09 SEQUENCING (NOT USED)

### 1.10 SCHEDULING (NOT USED)

### 1.11 WARRANTY



- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Nameplates and signs:
  - 1. One of the following or equal:
    - a. Brady.
    - b. Seton.
- B. Conductor and cable markers:
  - 1. Heat-shrinkable tubing:
    - a. One of the following or equal:
      - 1) Raychem.
      - 2) Brady.
      - 3) Thomas & Betts.
      - 4) Kroy.
  - 2. Non heat-shrinkable tubing:
    - a. One of the following or equal:
      - 1) Brady.
      - 2) Seton.
  - 3. Pre-printed slip-on sleeve markers:
    - a. The following or equal: Engineer knows of no equal.
      - 1) Grafoplast.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Nameplates:
  - 1. Colors:
    - a. Warning nameplates: White-center, red face.
    - b. Other nameplates: Black-center, white face.
  - 2. Laminated plastic engraving stock:
    - a. 3/32-inch thick material.
    - b. 2-ply.
    - c. With chamfered edges.
  - 3. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
    - a. No characters smaller than 1/8-inch in height.





- B. Signs:
  - 1. Automatic equipment and high voltage signs:
    - a. Suitable for exterior use.
    - b. In accordance with OSHA regulations.
- C. Conductor and cable markers:
  - 1. Machine printed black characters on white tubing.
  - 2. 10 point type or larger.

#### **2.04 MANUFACTURED UNITS (NOT USED)**

#### **2.05 EQUIPMENT (NOT USED)**

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES (NOT USED)**

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES (NOT USED)**

#### **2.11 SOURCE QUALITY CONTROL**

- A. Nameplates:
  - 1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
    - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Nameplates:
  - 1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
  - 2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
  - 3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
    - a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.



- C. Conductor and cable markers:
  - 1. Apply all conductor and cable markers before termination.
  - 2. Non heat-shrinkable tubing:
    - a. Tubing shall be sized for the wire and insulation on which it is to be placed.
    - b. Tubing shall be tight on the wire.
    - c. Characters shall face the open panel and shall read from left to right or top to bottom.
    - d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
- D. Signs and labeling:
  - 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
    - a. Fasten warning signs with round head stainless steel screws or bolts.
    - b. Locate and mount in a manner to be clearly legible to operations personnel.
  - 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
  - 3. Furnish and install warning signs on equipment that has more than one source of power.
    - a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
  - 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
    - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

- A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.



3.09 **ADJUSTING (NOT USED)**

3.10 **CLEANING (NOT USED)**

3.11 **PROTECTION (NOT USED)**

3.12 **SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16123

### 600-VOLT OR LESS WIRES AND CABLES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. 600 volt class or less wire and cable.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
  - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. CSA International (CSA).
- D. Insulated Cable Engineers Association (ICEA):
  - 1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
  - 2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
- E. National Fire Protection Association (NFPA):
  - 1. 72 - National Fire Alarm and Signaling Code.
  - 2. 101 - Life Safety Code.
- F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
  - 1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
  - 2. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.
  - 3. 1005 - Industrial Cabling Standard.
- G. Underwriter's Laboratories Inc., (UL):
  - 1. 44 - Thermoset-Insulated Wires and Cables.
  - 2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
  - 3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
  - 4. 1569 - Standard for Metal-Clad Cables.
  - 5. 2196 - Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
  - 6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.



### 03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
  - 1. AWG: American wire gauge.
  - 2. BCCS: Bare copper-covered steel.
  - 3. CPE: Chlorinated polyethylene.
  - 4. FEP: Fluorinated ethylene propylene.
  - 5. FHDPE: Foam high-density polyethylene.
  - 6. FPE: Foam polyethylene.
  - 7. OD: Outside diameter.
  - 8. PVC: Polyvinyl chloride.
  - 9. XHHW: Cross-linked high heat water resistant insulated wire.
- C. Definitions of terms and other electrical considerations as set forth in the:
  - 1. ASTM.
  - 2. ICEA.

### 1.04 SYSTEM DESCRIPTION

- A. Furnish and install the complete wire and cable system.

### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer of wire and cable.
  - 2. Insulation:
    - a. Type.
    - b. Voltage class.
  - 3. AWG size.
  - 4. Conductor material.
  - 5. Pulling compounds.
- C. Shop drawings:
  - 1. Show splice locations.
    - a. For each proposed splice location provide written justification describing why the splice is necessary.
- D. Test reports:
  - 1. Submit test reports for meg-ohm tests.
- E. Calculations:
  - 1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
    - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.



- b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

#### **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All wires and cables shall be UL listed and labeled.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

#### **1.09 SEQUENCING (NOT USED)**

#### **1.10 SCHEDULING (NOT USED)**

#### **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.13 OWNER`S INSTRUCTIONS (NOT USED)**

#### **1.14 MAINTENANCE (NOT USED)**

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. 600 volt class wire and cable:
    - a. General Cable.
    - b. Okonite Co.
    - c. Southwire Co.
    - d. Service Wire.
  - 2. 600 volt VFD cable:
    - a. General Cable.
    - b. Southwire Co.
    - c. Service Wire.
  - 3. Instrumentation class wire and cable:
    - a. Alpha Wire Co.
    - b. Belden CDT.
    - c. General Cable.
    - d. Okonite Co.
    - e. Rockbestos Surprenant Cable Corp.



4. Network cables:
  - a. General Cable.
  - b. Belden.
  - c. CommScope.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Conductors:
  1. Copper in accordance with ASTM B3.

## **2.04 MANUFACTURED UNITS**

- A. General:
  1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
  2. Permanently mark each wire and cable with the following at 24-inch intervals:
    - a. AWG size.
    - b. Voltage rating.
    - c. Insulation type.
    - d. UL symbol.
    - e. Month and year of manufacture.
    - f. Manufacturer's name.
  3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
    - a. Use integral color insulation for #2 AWG and smaller wire.
    - b. Wrap colored tape around cable larger than #2 AWG.
- B. 600 volt class wire and cable:
  1. Provide AWG or kcmil sizes as indicated on the Drawings:
    - a. When not indicated on the Drawings, size wire as follows:
      - 1) In accordance with the NEC:
        - a) Use 75 degree Celsius ampacity ratings.
        - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
      - 2) Provide #12 AWG minimum for power conductors.
      - 3) Provide #14 AWG minimum for control conductors.
  2. Provide Class B stranding in accordance with ASTM B8:
    - a. Provide Class C stranding where extra flexibility is required.
  3. Insulation:
    - a. XHHW-2.
    - b. 90 degree Celsius rating.
- C. 600 volt VFD cables:
  1. Conductor:
    - a. Provide Class B stranding in accordance with ASTM B8.
  2. Insulation:
    - a. Cross-linked Polyethylene.
    - b. 90 degree Celsius rating.
    - c. UL 44 Type RHH/RHW-2 or XHHW-2.
  3. Ground:
    - a. Provide Class B stranding in accordance with ASTM B8.





- b. 3 symmetrically placed bare copper conductors in direct contact with shield.
  - 4. Metallic shield:
    - a. Overall 5 mil bare copper tape shield with 50 percent overlap.
  - 5. Outer jacket:
    - a. UL 1277 Type PVC.
  - 6. Cable tray rated, UL Type TC-ER.
- D. Instrumentation class cable:
  - 1. Type TC.
  - 2. Suitable for use in wet locations.
  - 3. Voltage rating: 600 volts.
  - 4. Temperature rating:
    - a. 90 degree Celsius rating in dry locations.
    - b. 75 degree Celsius rating in wet locations.
  - 5. Conductors:
    - a. Insulation:
      - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
    - b. #16 AWG stranded and tinned.
    - c. Color code: ICEA Method 1:
      - 1) Pair: Black and white.
      - 2) Triad: Black, white and red.
      - 3) Multiple pairs or triads:
        - a) Color-coded and numbered.
  - 6. Drain wire:
    - a. #18 AWG.
    - b. Stranded, tinned.
  - 7. Jacket:
    - a. Flame retardant, moisture and sunlight resistant PVC.
    - b. Ripcord laid longitudinally under jacket to facilitate removal.
  - 8. Shielding:
    - a. Individual pair/triad:
      - 1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
    - b. Multiple pair or triad shielding:
      - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
      - 2) Completely isolate group shields from each other.
      - 3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    - c. All shielding to be in contact with the drain wire.
- E. Network cables:
  - 1. Category 6:
    - a. General:
      - 1) Provide Cat 6 cables meeting the standards set by TIA/EIA-568-C.2 and verified by third-party testing laboratory.
    - b. Conductors:
      - 1) #23 AWG solid bare annealed copper.
      - 2) 4 Bonded pairs.



- c. Drain wire:
  - 1) #24 AWG stranded (7/32) tinned copper.
- d. Insulation:
  - 1) Non-Plenum: Polyolefin.
  - 2) Plenum: Fluoropolymer.
- e. Shielding:
  - 1) None.
  - 2) Overall Foil Shield.
- f. Color code:
  - 1) Pair 1: White/blue stripe and blue.
  - 2) Pair 2: White/orange stripe and orange.
  - 3) Pair 3: White/green stripe and green.
  - 4) Pair 4: White/brown stripe and brown.
- g. Outer jacket:
  - 1) Non-Plenum: Flame-Retardant PVC.
  - 2) Plenum: Low-Smoke, Flame-Retardant PVC.
- h. Electrical characteristics:
  - 1) Voltage rating: 600VAC.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS (NOT USED)**

## **2.07 ACCESSORIES**

- A. Wire ties:
  - 1. One of the following or equal:
    - a. T&B, "Ty-Rap" cable ties.
    - b. Panduit, cable ties.
- B. Wire markers:
  - 1. As specified in Section 16075 - Identification for Electrical Systems.

## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES (NOT USED)**

## **2.11 SOURCE QUALITY CONTROL**

- A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.
- B. Test Type XHHW-2 in accordance with the requirements of UL 44.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**



### 3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Color-coding:
  - 1. Color-coding shall be consistent throughout the facility.
  - 2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Single phase system: Black for 1 hot leg, red for the other.
    - e. Neutral: White.
    - f. High phase or wild leg: Orange.
    - g. Equipment ground: Green.
  - 3. The following color code shall be followed for all 480/277 volt systems:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
    - d. Neutral: Gray.
    - e. Equipment ground: Green.
  - 4. The following color code shall be followed for all 120 VAC control wiring:
    - a. Power: Red.
    - b. Neutral: White.
  - 5. The following color code shall be followed for all general purpose DC control circuits:
    - a. Grounded conductors: White with blue stripe.
    - b. Ungrounded conductors: Blue.
  - 6. Switch legs shall be violet. 3-way switch runners shall be pink.
  - 7. Wires in intrinsically safe circuits shall be light blue.
  - 8. Wire colors shall be implemented in the following methods:
    - a. Wires manufactured of the desired color.
    - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
      - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
  - 1. Install wires only in approved raceways.
  - 2. Do not install wire:
    - a. In incomplete conduit runs.
    - b. Until after the concrete work and plastering is completed.
- D. Properly coat wires and cables with pulling compound before pulling into conduits:
  - 1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
    - a. Ideal Products.
    - b. Polywater Products.
    - c. 3M Products.
    - d. Greenlee Products.
    - e. Or equal as recommended by cable manufacturer.



f. Do not use oil, grease, or similar substances.

E. Cable pulling:

1. Prevent mechanical damage to conductors during installation.
2. For cables #1 AWG and smaller, install cables by hand.
3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
  - a. Make splices in manholes or pull boxes only.
  - b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:

1. Do not lace wires in gutter or panel channel.
2. Install all wire ties with a flush cutting wire tie installation tool:
  - a. Use a tool with an adjustable tension setting.
3. Do not leave sharp edges on wire ties.

I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:

1. Use ring type lugs if box lugs are not available on the equipment.

J. Lighting circuits:

1. Each circuit shall have a dedicated neutral.

K. Splices:

1. Provide continuous circuits from origin to termination whenever possible:
  - a. Obtain Engineer's approval prior to making any splices.
2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
  - a. Splice box NEMA rating requirements as specified in Section 16050 - Common Work Results for Electrical.
  - b. Make splices in labeled junction boxes for power conductors.
  - c. Make splices for control and instrument conductors in terminal boxes:
    - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
4. Power and control conductors routed in common raceways may be spliced in common junction boxes.



5. Clearly label junction and terminal boxes containing splices with the word "SPlice LOCATED WITHIN".
  6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
  7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
    - a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
  8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
    - a. A heat shrink insulating system listed for submersible applications.
    - b. Or an epoxy resin splicing kit.
- L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.
- M. Instrumentation class cable:
1. Install instrumentation class cables in separate raceway systems from power cables:
    - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
    - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
  2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
  3. Shield grounding requirements as specified in Section 16060 - Grounding and Bonding.
- N. Copper Ethernet cables:
1. Comply with TIA/EIA-568-C.2.
  2. Pathways:
    - a. For initial installation, the maximum fill capacity for pathways (i.e. conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
    - b. Conduit should be run in the most direct route possible with no more than two 90 degree bends between pull boxes and serve no more than 3 outlet boxes.
  3. Cable bend radius:
    - a. Proper cable bend radius control must be maintained throughout the pathways. The bend radius needs to be at a minimum 10 times the cable diameter.
  4. Cable pulling:
    - a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
    - b. The maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
    - c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.



5. Cable management:
  - a. Organize and manage cables for quick and easy moves, adds and changes.
6. Testing:
  - a. All cables and termination hardware shall be 100 percent tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of TIA/EIA-568-C.1 Section 11.
    - 1) All pairs of each installed cable shall be verified prior to system acceptance.
    - 2) Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed.
  - b. All twisted-pair copper cable links shall be tested for compliance to the requirements in TIA/EIA/568-C.2 for the appropriate Category of cabling installed.
  - c. All cables shall be tested in accordance with the contract documents, TIA/EIA standards, and best industry practice.
  - d. The field test equipment shall meet the requirements of TIA/EIA-568-C. The appropriate level III tester shall be used to verify Category 6 cabling.
  - e. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-C.1.
  - f. Visually inspect cable placement, cable termination, grounding and bonding, equipment and labeling of all components.
  - g. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors.
    - 1) Test operation of shorting bars in connection blocks.
    - 2) Test cables after termination but not cross-connection.
      - a) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.2.
        - (1) Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
        - (2) Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
7. Separation from EMI sources:
  - a. Comply with TIA/EIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.



- 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches
  - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
  - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
  - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
- O. Signal cable:
  - 1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.
- P. Wiring allowances:
  - 1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
  - 2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Grounding:
  - 1. As specified in Section 16060 - Grounding and Bonding.





3.09 **ADJUSTING (NOT USED)**

3.10 **CLEANING (NOT USED)**

3.11 **PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 **SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16130

### CONDUITS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Metallic conduits.
  - 2. Nonmetallic conduits.
  - 3. Conduit bodies.
  - 4. Conduit fittings and accessories.
  - 5. Conduit installation.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American National Standards Institute (ANSI):
  - 1. C80.1 - Electrical Rigid Steel Conduit.
  - 2. C80.3 - Steel Electrical Metallic Tubing.
  - 3. C80.5 - Electrical Rigid Aluminum Conduit.
  - 4. C80.6 - Electrical Intermediate Metal Conduit.
- C. National Electrical Manufacturer's Association (NEMA):
  - 1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
  - 2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
  - 3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
  - 4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
  - 5. TC13 - Electrical Nonmetallic Tubing.
  - 6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- D. Underwriters Laboratories (UL):
  - 1. 1 - Standard for Flexible Metal Conduit.
  - 2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
  - 3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
  - 4. 360 - Standard for Liquidtight Flexible Steel Conduit.
  - 5. 651 - Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
  - 6. 651B - Standard for Continuous Length HDPE Conduit.
  - 7. 797 - Standard for Electrical Metallic Tubing - Steel.
  - 8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
  - 9. 1653 - Standard for Electrical Nonmetallic Tubing.
  - 10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.
  - 11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.



## **DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
  - 1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
  - 2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
  - 3. GRC: Galvanized rigid steel conduit.
  - 4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
  - 5. EMT: Electrical metallic tubing.
  - 6. PVC: Polyvinyl chloride rigid nonmetallic conduit.
  - 7. SLT: Sealtight-liquidtight flexible conduit.
  - 8. EFLX: Explosion proof flexible conduit.
  - 9. RAC: Rigid aluminum conduit.
  - 10. NPT: National pipe thread.

## **1.04 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
  - 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
- C. Certifications:
  - 1. Furnish PVC-coated conduit manufacturer's certification for each installer.
- D. Record Documents:
  - 1. Incorporate all changes in conduit routing on electrical plan drawings.
  - 2. Dimension underground and concealed conduits from building lines.
  - 3. Furnish hard copy drawings.

## **1.05 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.
- C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Do not expose non-metallic conduit to direct sunlight.



- C. Do not store conduit in direct contact with the ground.
- D. Do not store aluminum conduit in contact with concrete.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 SEQUENCING**

- A. Before installing any conduit or locating any device box:
  - 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
  - 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

## **1.09 SCHEDULING (NOT USED)**

## **1.10 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.11 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.13 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Galvanized rigid steel conduit:
  - 1. One of the following or equal:
    - a. Western Tube and Conduit.
    - b. Allied Tube and Conduit.
    - c. Wheatland Tube Co.
- B. PVC-coated rigid steel conduit:
  - 1. One of the following or equal:
    - a. Robroy Ind.
    - b. Ocal, Inc.
    - c. Calbond.
    - d. Allied.
    - e. NEC, Inc. BlackGuard.
- C. Sealtight-liquidtight flexible conduit:
  - 1. One of the following or equal:
    - a. Southwire.



- b. AFC Cable Systems.
  - c. Electri-Flex Co.
  - d. Anaconda.
- D. Explosion proof flexible conduit:
  - 1. One of the following or equal:
    - a. Appleton.
    - b. Crouse-Hinds.
    - c. Hubbell Killark.
- E. Conduit bodies:
  - 1. One of the following or equal:
    - a. Crouse-Hinds.
    - b. Appleton.
    - c. O-Z/Gedney.
    - d. Ocal, Inc.
    - e. Robroy Ind.
    - f. Calbond.
    - g. Carlon.
- F. Joint compound:
  - 1. The following or equal:
    - a. Thomas and Betts.
- G. Galvanized rigid steel conduit expansion fittings:
  - 1. One of the following or equal:
    - a. Crouse-Hinds.
    - b. Appleton.
    - c. O-Z/Gedney.
- H. PVC-coated rigid steel conduit expansion fittings:
  - 1. One of the following or equal:
    - a. Ocal, Inc.
    - b. Robroy Ind.
    - c. NEC, Inc. BlackGuard.
- I. Conduit sleeve:
  - 1. One of the following or equal:
    - a. Crouse-Hinds.
    - b. Appleton.
    - c. O-Z/Gedney.
- J. Conduit seals:
  - 1. One of the following or equal:
    - a. Appleton.
    - b. Crouse-Hinds.
    - c. O-Z/Gedney.
- K. Conduit hangers and supports:
  - 1. As specified in Section 16070 - Hangers and Supports.
- L. Conduit through wall and floor seals:
  - 1. The following or equal:



- a. O-Z/Gedney:
  - 1) Type "WSK."
  - 2) Type "CSM."

## **2.02 SYSTEM DESCRIPTION**

- A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

## **2.03 EXISTING PRODUCTS (NOT USED)**

## **2.04 MATERIALS (NOT USED)**

## **2.05 MANUFACTURED UNITS (NOT USED)**

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS**

- A. GRC:
  - 1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
    - a. Running conduit threads are not acceptable.
  - 2. Hot-dip galvanized inside and out:
    - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
    - b. Electro-galvanizing is not acceptable.
  - 3. Manufactured in accordance with:
    - a. UL-6.
    - b. ANSI C80.1.
- B. PCS:
  - 1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
  - 2. Coated conduit NEMA Standard RN-1:
    - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
  - 3. Factory-bonded PVC jacket:
    - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
    - b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
    - c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
    - d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
      - 1) Confirm bond with certified test results.
  - 4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
    - a. Nominal thickness of 0.002 inch.
    - b. Conduits having areas with thin or no coating are not acceptable.



- c. All threads shall be coated with urethane.
5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
6. PCS conduit bodies and fittings:
  - a. Malleable iron.
  - b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
  - c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
  - d. 0.002-inch interior urethane coating.
  - e. Utilize the PVC coating as an integral part of the gasket design.
  - f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
  - g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
    - 1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
    - 2) The sleeve shall provide a vapor- and moisture resistant seal at every connection.
- C. SLT:
  1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    - a. General purpose:
      - 1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
    - b. Oil-resistant:
      - 1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
  2. Sunlight-resistant, weatherproof, and watertight.
  3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
  4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
  5. Overall PVC jacket.
  6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.
- D. EFLX:
  1. Suitable for the hazardous Class and Group where installed:
    - a. As specified in Section 16050 - Common Work Results for Electrical.
  2. Metallic braid shall provide continuous electrical path.
  3. Stainless steel construction.
  4. Provide fittings and unions as required for the installation.
- E. PVC:
  1. Extruded from virgin PVC compound:
    - a. Schedule 40 unless otherwise specified.
    - b. Schedule 80 extra-heavy wall where specified.
  2. Rated for 90 degrees Celsius conductors or cable.
  3. Rated for use in direct sunlight.





- F. Conduit bodies:
  - 1. Material consistent with conduit type:
    - a. Malleable iron bodies and covers when used with Type GRC.
    - b. Cast aluminum bodies and covers when used with Type RAC.
    - c. PVC bodies and covers when used with Type PVC.
    - d. PVC-coated malleable iron bodies and covers when used with Type PCS.
  - 2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
    - a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
  - 3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

## 2.08 ACCESSORIES

- A. Connectors and fittings:
  - 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:
  - 1. Construction:
    - a. Malleable iron or zinc-plated steel when used with steel conduit.
    - b. Aluminum when used with aluminum conduit.
    - c. Positive metallic conduit end stop.
    - d. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    - e. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.
- C. Insulated grounding bushings:
  - 1. Construction:
    - a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
    - b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    - c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.
- D. Electrical unions (Erickson Couplings):
  - 1. Construction:
    - a. Malleable iron for use with steel conduit.
    - b. Aluminum for use with aluminum conduit.
    - c. Concrete tight, 3-piece construction.
    - d. Rated for Class I Division 1 Group D in hazardous areas.
- E. SLT fittings:
  - 1. Construction:
    - a. Malleable iron.
    - b. Furnished with locknut and sealing ring.
    - c. Liquidtight, raintight, oiltight.
    - d. Insulated throat.
    - e. Furnish as straight, 45-degree elbows, and 90-degree elbows.



- f. Designed to prevent sleeving:
        - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
      - g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
      - h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
    - 2. Corrosion-resistant and outdoor SLT fittings:
      - a. Construction:
        - 1) PVC-coated liquidtight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
        - 2) Insulated throat and an integral sealing ring.
- F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
  - 1. Construction:
    - a. Insulated throat.
    - b. PVC-coated when used in corrosive areas.
    - c. Bonding locknut.
    - d. Recessed neoprene o-ring to ensure watertight and dusttight connector.
    - e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
    - f. 1-1/2-inch through 6-inch malleable iron zinc plated.
    - g. Aluminum with aluminum conduit.
  - 2. Usage:
    - a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- G. Sealing fittings:
  - 1. Construction:
    - a. 40-percent wire fill capacity.
    - b. PVC-coated when used in corrosive areas.
    - c. Malleable ductile iron with steel conduit.
    - d. Aluminum with aluminum conduit.
    - e. Type EYDX where drains are required.
    - f. Type EYSX where drains are not required.
    - g. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.
  - 2. Sealing compound:
    - a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
    - b. Approved for the conditions and use.
      - 1) Not affected by surrounding atmosphere or liquids.
    - c. Melting point shall be 200 degrees Fahrenheit minimum.



- H. PVC fittings:
  - 1. Materials:
    - a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
    - b. All metal hardware shall be stainless steel.
- I. Through wall and floor seals:
  - 1. Materials:
    - a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish Aluminum.
    - b. Grommet: Neoprene.
    - c. Pressure rings: PVC-coated steel.
    - d. Disc material: PVC-coated steel.
- J. Expansion/deflection couplings:
  - 1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
  - 2. Shall allow movement of 3/4 inch from the normal in all directions.
  - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
  - 4. Constructed to maintain electrical continuity of the conduit system.
  - 5. Materials:
    - a. End couplings: Bronze or galvanized ductile iron.
    - b. Sleeve: Neoprene.
    - c. Bands: Stainless steel.
    - d. Bonding jumper: Tinned copper braid.
- K. Expansion couplings:
  - 1. Shall allow for expansion and contraction of conduit:
    - a. Permitting 8-inch movement, 4 inches in either direction.
  - 2. Constructed to maintain electrical continuity of the conduit system.
  - 3. Materials:
    - a. Head: Malleable or ductile iron.
    - b. Sleeve: Steel.
    - c. Insulating bushing: Phenolic.
    - d. Finish: Hot-dip galvanized.
    - e. Aluminum when used with Type RAC.
    - f. PVC-coated when used with Type PCS.
- L. Conduit markers:
  - 1. As specified in Section 16075 - Identification for Electrical Systems.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **ART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
  - 1. Conduit routing:
    - a. The electrical drawings are diagrammatic in nature:
      - 1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
      - 2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
        - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
        - b) Make changes in conduit routing due to the relocation of equipment.
      - 3) The electrical drawings do not indicate all required junction boxes and pull boxes:
        - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
          - (1) To meet cable manufacturer's pulling tension requirements.
          - (2) To limit total conduit bends between pull locations.
        - b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
    - b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
      - 1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
      - 2) Perform any changes resulting in additional conduits, or extra work from such deviations.
      - 3) Incorporate any deviations on the Record Documents.
  - 2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
  - 3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
    - a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
    - b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
    - c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
    - d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.



4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
    - a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
  5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
  6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
    - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
    - b. Make changes in direction with long radius bends or with conduit bodies.
  7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
  8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
    - a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
    - b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
  9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
  10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
  11. Install conduits through wall and floor seals where indicated on the Drawings.
  12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    - a. Remove and replace conduits through which mandrel will not pass.
  13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
  14. Install complete conduit systems before conductors are installed.
  15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
  16. Underground conduits:
    - a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
      - 1) As specified in Section 16133 - Duct Banks.
    - b. Make underground conduit size transitions at handholes and manholes.
    - c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    - d. Seal around conduit penetrations of below grade walls with a mechanical seal.
- C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:



2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
  3. Minimum conduit size:
    - a. 3/4-inch for exposed conduits.
    - b. 1-inch for underground or in-slab conduits.
  4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.
- D. Hazardous areas:
1. As specified in Section 16050 - Common Work Results for Electrical for hazardous areas and specific Class and Division.
  2. As specified in Section 16052 - Hazardous Classified Area Construction for hazardous area conduit installation requirements.
- E. Conduit usage:
1. Exposed conduits:
    - a. Rigid conduit:
      - 1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
      - 2) Minimum size: 3/4-inch.
    - b. Flexible conduit:
      - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
        - a) Use Type SLT with rigid metallic conduit.
        - b) Use Type EFLX in Class I Division 1 locations.
      - 2) Minimum size: 3/4-inch:
        - a) 1/2 when required for connection to instruments.
      - 3) Maximum length:
        - a) Fixed equipment:
- | Conduit Trade Size | Flexible Conduit Length (inch) |
|--------------------|--------------------------------|
| 3/4                | 18                             |
| 1                  | 18                             |
| 1-1/4              | 18                             |
| 1-1/2              | 18                             |
| 2                  | 36                             |
| 2-1/2              | 36                             |
| 3                  | 36                             |
| 3-1/2              | 38                             |
| 4                  | 40                             |
- b) Removable instruments or hinged equipment:
    - (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.



2. Concrete-encased and embedded conduits:
  - a. Straight runs and bends less than 45 degrees:
    - 1) Type PVC Schedule 40.
  - b. Bends with total deflection greater than 45 degrees;
    - 1) PCS,
  - c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
    - 1) PCS.
  - d. Minimum size:
    - 1) 2-inch in duct banks.
    - 2) 1-inch for in-slab conduits.
    - 3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.
3. Direct-buried and sand-bedded duct bank conduits:
  - a. Type PCS.
  - b. Minimum size: 1-inch.
4. Below-slab conduits:
  - a. Type PCS.
  - b. Minimum size: 1-inch.
5. PVC-coated rigid metallic conduit:
  - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
6. GRC:
  - a. Conduit shall be cut square and reamed before threading.

F. Conduit joints and bends:

1. General:
  - a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
  - b. Keep bends and offsets in conduit runs to an absolute minimum.
  - c. All bends shall be symmetrical.
  - d. The following conduit systems shall use large-radius sweep elbows:
    - 1) Underground conduits.
    - 2) Conduits containing fiber optic cables.
  - e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
  - f. Make field bends with a radius of not less than the requirements found in the NEC:
    - 1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
    - 2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
      - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
      - b) For the serving utilities, make bends to meet their requirements.
  - g. Replace all deformed, flattened, or kinked conduit.
2. Threaded conduit:
  - a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the





couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.

- b. Thoroughly ream conduit after threads have been cut to remove burrs.
  - c. Use bushings or conduit fittings at conduit terminations.
  - d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It."
  - e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
    - 1) Apply to the male threads and tighten joints securely.
    - 2) Clean excess sealant from exposed threads after assembly.
  - f. Securely tighten all threaded connections.
  - g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
3. PVC:
- a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
  - b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
    - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit sealing and drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas:
  - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
  - b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
  - c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
    - 1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
  - d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
  - e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.

H. Conduit supports:

1. General:
  - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
    - 1) As specified in Section 16070 - Hangers and Supports.



- 2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
        - b. Support conduit at the intervals required by the NEC.
        - c. Perforated strap and plumbers tape are not acceptable for conduit supports.
    2. Conduit on concrete or masonry:
      - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      - b. Use preset inserts in concrete when possible.
      - c. Use pipe spacers (clamp backs) in wet locations.
    3. Suspended conduit:
      - a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
      - b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
    4. Supports at structural steel members:
      - a. Use beam clamps.
      - b. Drilling or welding may be used only as specified or with approval of the Engineer.
    5. PVC-coated rigid metal systems:
      - a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
      - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.
  - I. Expansion or expansion/deflection fittings:
    1. General:
      - a. Align expansion coupling with the conduit run to prevent binding.
      - b. Follow manufacturer's instructions to set the piston opening.
      - c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      - d. Furnish fittings of the same material as the conduit system.
    2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
      - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
  - J. Empty conduits:
    1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
    2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
      - a. Keep ends sealed until immediately before pulling conductors.



K. Miscellaneous:

1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
  - a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab, per the Typical Details.

**3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## **SECTION 16133**

### **DUCT BANKS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Electrical underground duct banks.
  - 2. Duct bank installation requirements.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.04 SYSTEM DESCRIPTION**

- A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. PVC conduit spacers.
  - 2. Detectable underground marking tape.
  - 3. Pull line.
- C. Provide applicable submittal documents as specified in:
  - 1. Section 02318 - Trenching.
  - 2. Section 03200 - Concrete Reinforcing.
  - 3. Section 03300 - Cast-In-Place Concrete.
- D. Shop drawings:
  - 1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.



2. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
  - a. Submit shop drawings detailing the new building footer crossing locations and plan drawings labeling all equipment to be installed on top of the new routing for approval by the project Structural Engineer.

## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Conduit spacers:
  1. One of the following or equal:
    - a. Carlon Snap-Loc.
    - b. Cantex.
    - c. Osburn Associates, Inc.
- B. Detectable underground marking tape:
  1. One of the following or equal:
    - a. Blackburn Manufacturing Co.
    - b. Pro-Line Safety Products.
    - c. Panduit.
- C. Pull line:
  1. One of the following or equal:



- a. Arnco.
- b. Greenlee.
- c. Osburn Associates, Inc.

- D. Duct seal:
  - 1. The following or equal:
    - a. OZ Gedney type DUX.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Provide conduit as specified in Section 16130 – Conduits:
  - 1. Use duct suitable for use with 194 degree Fahrenheit rated conductors.
- B. Provide reinforcing steel as specified in Section 03200 - Concrete Reinforcing:
  - 1. Provide minimum Number 4 reinforcing steel.

## **2.04 MANUFACTURED UNITS**

- A. Conduit spacers:
  - 1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
  - 2. Saddle type.
  - 3. Non-metallic, non-corrosive, non-conductive.
  - 4. Interlocking type:
    - a. Vertical interlocking.
    - b. Horizontal interlocking.
  - 5. Suitable for concrete encasement.
  - 6. Molded-in rebar holder.
  - 7. Accommodates 2-inch through 6-inch conduit sizes.
  - 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull line:
  - 1. Minimum 1/4-inch wide, flat design.
  - 2. Polyester.
  - 3. Minimum pulling strength 1,200 pounds.
- C. Detectable marking tape:
  - 1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
  - 2. Aluminum core laminated between polyethylene film.
  - 3. 6-inch wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW" or equivalent.
- D. Duct seal:
  - 1. Non-hardening sealing compound.
  - 2. Flexible, can be applied by hand.
  - 3. UL Listed for use with installed conductors.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS (NOT USED)**



## **2.07 ACCESSORIES (NOT USED)**

### **2.08 MIXES**

- A. Concrete mix requirements as specified in Section 03300 - Cast-In-Place Concrete.
- B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300 - Cast-In-Place Concrete.

### **2.09 FABRICATION (NOT USED)**

### **2.10 FINISHES (NOT USED)**

### **2.11 SOURCE QUALITY CONTROL (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Duct banks:
  - 1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
  - 2. Damage minimization:
    - a. Conduit should not be left exposed in an open trench longer than is necessary.
    - b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
  - 3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
  - 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
  - 5. Install underground ducts to be self-draining:
    - a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
    - b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
    - c. Slope a minimum of 1/4 inch per 10 feet.
  - 6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.





7. Install pull line in spare conduits:
  - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
  - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- C. Trenching:
  1. Perform trenching as specified in Section 02318 - Trenching.
  2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
  3. Whenever possible, use the walls of the trench as forms for concrete encasement:
    - a. Forms are required where the soil is not self-supporting.
  4. Avoid damaging existing ducts, conduits, cables, and other utilities.
- D. Duct spacing:
  1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
    - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
  2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
    - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
      - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
        - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
  3. Spacers shall not be located at the center of a bend:
    - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
    - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.
- E. Terminating:
  1. Use bell ends in duct at entrances into cable vaults.
  2. Make conduit entrances into cable vaults tangential to walls of cable vault.
  3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
  4. Install duct seal in all conduits including spare conduits, at entrance to manholes/handholes, and building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
  5. New manhole or handhole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.
- F. Concrete:
  1. Install concrete as specified in Section 03300 - Cast-In-Place Concrete.
  2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
    - a. Tie wire shall not act as a substitute for spacers.
  3. Install minimum 3-inch cover around conduit and rebar.



4. Consolidation of encasement concrete around duct banks shall be by hand puddling, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:

1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING**

- A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide shoring and pumping to protect the excavation and safety of workers.
- C. Protect excavations with barricades as required by applicable safety regulations.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16134

### BOXES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Device boxes.
  - 2. Raceway system boxes.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. Standard Specifications for Highway Bridges.
- C. ASTM International (ASTM):
  - 1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
  - 2. D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
  - 3. D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
  - 4. D570 - Standard Test Method for Water Absorption of Plastics.
  - 5. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
  - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
  - 7. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
- D. Joint Industry Conference (JIC).
- E. Underwriters Laboratories, Inc. (UL):
  - 1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
  - 1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
  - 2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.



1.04

## **SYSTEM DESCRIPTION**

- A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.
- B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

## **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer.
  - 2. Materials.
  - 3. Dimensions:
    - a. Height.
    - b. Width.
    - c. Depth.
    - d. Weight.
    - e. NEMA rating.
  - 4. Conduit entry locations.
  - 5. Catalog cut sheets.
  - 6. Installation instructions.
- C. Shop drawings:
  - 1. Include identification and sizes of pullboxes.

## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
  - 1. Outlet boxes shall comply with all applicable standards of:
    - a. JIC.
    - b. NEC.
    - c. NEMA.
    - d. UL.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING**

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Cast device boxes:
    - a. Appleton.
    - b. Crouse - Hinds.
    - c. OZ/Gedney.
  - 2. Stainless steel enclosures:
    - a. Hoffman.
    - b. Stahlin.
    - c. Rittal.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS**

- A. Cast device boxes:
  - 1. Construction:
    - a. With internal green ground screw.
    - b. Furnished with a suitable gasketed cover.
    - c. With integral cast mounting lugs when surface mounted.
    - d. Conduit sizes range from 3/4 inch to 1 inch.
    - e. Tapered threaded hubs with integral bushing.
  - 2. Malleable iron boxes:
    - a. Conforming to ASTM A47 Grade 32510.
- B. Plastic coated cast device boxes:
  - 1. Construction:
    - a. With internal green ground screw.
    - b. Furnished with a suitable gasketed cover.
    - c. With integral cast mounting lugs when surface mounted.
    - d. Conduit sizes range from 3/4 inch to 1 inch.
    - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.



- f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
    - g. With pressure sealing sleeve to protect the connection with conduit.
- C. Class I Division 1 areas:
  - 1. Provide boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
    - a. The approval ratings must be permanently marked on each item.
- D. Class I, Division 2 areas:
  - 1. For boxes not containing arcing parts:
    - a. As specified in Section 16050 - Common Work Results for Electrical.
    - b. Pressed metal boxes are not allowed.
  - 2. For boxes containing arcing parts provide:
    - a. Boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
      - 1) The approval ratings must be permanently marked on each item.
  - 3. Cast iron Cast copper - free aluminum box and cover.
  - 4. Precision machined flame path between box and cover with neoprene o-ring.
  - 5. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
  - 6. External flange.
  - 7. Provisions for mounting pan.
  - 8. Ground lug.
  - 9. Stainless steel:
    - a. NEMA Type 4X:
      - 1) Boxes in locations subject to flooding or temporary submersion:
        - a) NEMA Type 6.
    - b. Fabricated from 14-gauge Type 316 stainless steel.
    - c. All seams continuously welded.
    - d. Door:
      - 1) Rolled lip around 3 sides.
      - 2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
    - e. Neoprene door gasket to provide a watertight seal:
      - 1) Attached with an adhesive.
      - 2) Retained by a retaining strip.
    - f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
      - 1) With a hasp and staple for padlocking.
    - g. Provide large enclosures with door and body stiffeners for extra rigidity.
    - h. No holes or knockouts.
    - i. Finish:
      - 1) Brushed.
    - j. Stainless steel external mounting brackets when surface mounted.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS (NOT USED)**



## **2.07 ACCESSORIES**

- A. Fasteners:
  - 1. Electroplated or stainless steel in boxes with wiring devices.
  - 2. Screws, nuts, bolts, and other threaded fasteners:
    - a. Stainless steel.
- B. Provide breather and drain fittings where appropriate.
- C. Internal panels:
  - 1. Provide internal panels where required for mounting of terminal strips or other equipment.
  - 2. With plated steel shoulder studs.
  - 3. Steel with white polyester powder finish.

## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES (NOT USED)**

## **2.11 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
  - 1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.
  - 2. Provide outlet box materials to match the conduit system:
    - a. GRC - Cast ferrous boxes.
    - b. PCS - PVC coated cast ferrous boxes.
    - c. PVC - PVC boxes.
  - 3. Solid type gang boxes:
    - a. For more than 2 devices.
    - b. For barriered outlets.
  - 4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
    - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
    - b. Use stainless steel or nylon materials for spacers.
  - 5. Use cast malleable iron boxes when box must support other devices.





6. Boxes serving luminaires or devices:
    - a. Use as pullboxes wherever possible.
  7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
  8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
    - a. Furnish wireways for discrete and analog/DC wiring.
    - b. Separate analog wiring from 120 V discrete or power wiring.
  9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
  10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
- C. Outlet boxes:
1. Locate outlet boxes as indicated on the Drawings:
    - a. Adjust locations so as not to conflict with structural requirements or other trades.
  2. Use deep threaded-hub malleable iron or aluminum boxes:
    - a. In hazardous areas.
    - b. Where exposed to the weather.
    - c. In unheated areas.
    - d. Where subject to mechanical damage:
      - 1) Defined as exposed boxes less than 10 feet above the floor.
    - e. To act as a pullbox for conductors in a conduit system.
    - f. Accommodate wiring devices.
  3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
  4. Outlet boxes may be used as junction boxes wherever possible.
- D. Pullboxes and junction boxes:
1. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
  2. Install pullboxes such that access to them is not restricted.
- E. For boxes not indicated:
1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.
  2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
    - a. One-piece, galvanized, pressed steel.
  3. Ceiling boxes for flush mounting in concrete:
    - a. Deep, galvanized, pressed steel.
  4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
    - a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
  5. Outlet, control station, and junction boxes for installation in corrosive locations:
    - a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
    - b. Furnished with mounting lugs.



F. Hazardous locations:

1. All metallic boxes, fittings, and joints shall utilize threaded connections to the conduit system.
2. All threaded connections shall be wrench tightened so that at least 5 threads are fully engaged.
3. Conduits entering and exiting metallic boxes in Class I Division 2 areas shall utilize approved grounding bushings to bond the conduits together.
4. Provide the following types of conduit bodies and boxes:
  - a. Malleable iron bodies and boxes with GRC or IMC conduit systems.
  - b. PVC coated conduit bodies and boxes with PCS conduit systems.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 REINSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16150

### LOW VOLTAGE WIRE CONNECTIONS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Wire connecting devices.
  - 2. Terminations.
  - 3. Splices.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
  - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
  - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SYSTEM DESCRIPTION

- A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Catalog cut sheets.
  - 2. Installation instructions.

##### 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All materials shall be UL listed.



## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Manufacturers for each type of technology are specified with the equipment in this Section.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**

## **2.05 EQUIPMENT**

- A. Control connections:
  - 1. Use insulated ring type wire terminators for connections to all screw terminals:
    - a. With chamfered/funneled terminal barrel entry.
    - b. Deep internal serrations.
    - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
    - d. Electroplated-tin copper conductor.
    - e. Manufacturers: The following or equal:
      - 1) Thomas and Betts, Stakon.
  - 2. For process equipment connections work from manufacturer's drawings.



- B. Joints, splices, taps, and connections:
1. 600-volt conductors:
    - a. Use solderless connectors.
    - b. Use only plated copper alloy connectors or lugs:
      - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
    - c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
    - d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
      - 1) Manufacturers: The following or equal:
        - a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
    - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
      - 1) Manufacturers: One of the following or equal:
        - a) Burndy.
        - b) Thomas and Betts.
    - f. Heat shrink tubing:
      - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
      - 2) Minimum shrink ratio: 4 to 1.
      - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
      - 4) Internally applied adhesive sealant.
      - 5) Cross-linked polyolefin:
        - a) Manufacturers: One of the following or equal:
          - (1) 3M, ITCSN.
          - (2) Thomas & Betts, Shrink-Kon.
  2. Instrumentation class cable splices:
    - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
    - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
    - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
    - d. Two-part mold body with tongue and groove seams and built in spacer webbing.
    - e. Manufacturers: The following or equal:
      - 1) 3M, Scotchcast 72-N.
- C. Insulating tape:
1. General purpose insulating tape:
    - a. Minimum 7 mil vinyl tape.
    - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
    - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
    - d. Flame retardant, hot- and cold- weather resistant, UV resistant.
    - e. For use as a primary insulation for wire cable splices up to 600 VAC.
    - f. Meeting and complying with:
      - 1) ASTM D3005 Type I.
      - 2) UL 510.
      - 3) CSA C22.2.



- g. Manufacturers: The following or equal:
  - 1) 3M, Scotch Number Super 33+.
- 2. General-purpose color-coding tape:
  - a. Minimum 7 mil vinyl tape.
  - b. Suitable for application on PVC and polyethylene jacketed cables.
  - c. For use indoors and outdoors in weather protected enclosures.
  - d. Available with the following colors:
    - 1) Red.
    - 2) Yellow.
    - 3) Blue.
    - 4) Brown.
    - 5) Gray.
    - 6) White.
    - 7) Green.
    - 8) Orange.
    - 9) Violet.
  - e. For use as phase identification, marking, insulating, and harnessing.
  - f. Meeting and complying with:
    - 1) UL 510.
    - 2) CSA C22.2.
  - g. Manufacturers: The following or equal:
    - 1) 3M, Scotch Number 35.

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES (NOT USED)**

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES (NOT USED)**

#### **2.11 SOURCE QUALITY CONTROL (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Load connections:
  - 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.





- C. Zero to 600-volt systems:
  - 1. Make all connections with the proper tool and die as specified by the device manufacturer.
  - 2. Use only tooling and dies manufactured by the device manufacturer.
  - 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
  - 4. Number all power and control wires before termination.
- D. Motor connections (600 volts and below):
  - 1. Terminate all leads and wires with compression type ring lugs.
  - 2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
  - 3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
    - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
    - b. Shrink cap with low heat as recommended by manufacturer.
  - 4. Wire markers shall be readable after boot installation.
  - 5. Manufacturers: The following or equal:
    - a. Raychem, MCK.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **3.09 ADJUSTING (NOT USED)**

#### **3.10 CLEANING (NOT USED)**

#### **3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16285

### SURGE PROTECTIVE DEVICES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. High-energy surge protective devices.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
  - 2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
  - 3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
  - 4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits.
- C. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. Underwriters Laboratory:
  - 1. 1449, 4th Edition, Standard for Surge Protective Devices.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. NEMA:
  - 1. Type 1 enclosure in accordance with NEMA 250.
  - 2. Type 4 enclosure in accordance with NEMA 250.
  - 3. Type 4X enclosure in accordance with NEMA 250.
  - 4. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
  - 1. SPD: Surge protective device.
  - 2. SAD: Silicon avalanche diode.
  - 3. MOV: Metal oxide varistor.
  - 4. MCOV: Maximum continuous operating voltage.
  - 5.  $I_n$ : Nominal discharge current.
  - 6. VPR: Voltage protection rating.
  - 7. SCCR: Short circuit current rating.



1.04

## **SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
  - 2. Manufacturer's catalog cut sheets indicating:
    - a. Manufacturer and model numbers.
    - b. Ratings of each SPD including but not limited to:
      - 1) Short circuit current rating.
      - 2) Nominal discharge current.
      - 3) Maximum continuous operating voltage.
      - 4) Voltage protection rating.
      - 5) System voltage.
      - 6) System frequency.
      - 7) Surge current capacity.
  - 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
    - a. Overcurrent protection.
    - b. UL 1449.
- C. Shop drawings:
  - 1. Provide electrical and mechanical drawings by the manufacturer that detail:
    - a. Unit dimensions.
    - b. Weights.
    - c. Components.
    - d. Field connection locations.
    - e. Mounting provisions.
    - f. Connection details.
    - g. Wiring diagram.
- D. Operation and maintenance manuals:
  - 1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

## **1.05 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
  - 1. Institute of Electrical and Electronics Engineers (IEEE C62.41.1, C62.41.2, C62.45, C62.62).
  - 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
  - 3. National Electrical Manufacturer Association.
  - 4. National Fire Protection Association (NFPA 20, 75 and 780).
  - 5. National Electric Code (NFPA 70).
  - 6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283).
  - 7. International Electrotechnical Commission (IEC 801).



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 SEQUENCING**

- A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

## **1.09 SCHEDULING (NOT USED)**

## **1.10 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Extended warranty:
  - 1. Furnish a manufacturer's full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
  - 2. Warranty shall include:
    - a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
    - b. A 24-hour toll-free 800-number for warranty support.

## **1.11 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.13 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Liebert.
  - 2. Eaton.
  - 3. Schneider Electric.
  - 4. General Electric.

## **2.02 SYSTEM DESCRIPTION**

- A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.



### 2.03 EXISTING PRODUCTS (NOT USED)

### 2.04 MATERIALS (NOT USED)

### 2.05 MANUFACTURED UNITS

- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.
- B. Electrical requirements:
1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
  2. MCOV:
    - a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
  3. Operating frequency:
    - a. 47 to 63 hertz.
  4. SCCR:
    - a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
    - b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
  5. Nominal discharge current  $I_n$ :
    - a. 20 kA.
  6. Maximum VPR:

Modes	<u>240/120</u>	<u>208Y/120</u>	480Y/277	480V
L-N, L-G, N-G	900	900	1,500	1,500
L-L	1,200	1,200	2000	2,000

7. Peak surge current:
    - a. Service entrance locations:
      - 1) 240 kA per phase minimum.
      - 2) 120 kA per mode minimum.
    - b. Branch locations:
      - 1) 120 kA per phase, minimum.
      - 2) 60 kA per mode minimum.
- C. Protection modes:
1. Provide SPD protection modes as follows:
    - a. Line to Neutral (L-N) where applicable.
    - b. Line to Ground (L-G).
    - c. Neutral to Ground (N-G), where applicable.
- D. Environmental requirements:
1. Storage temperature:
    - a. -40 degrees to 122 degrees Fahrenheit.
  2. Operating temperature:
    - a. 32 degrees to 140 Fahrenheit.
  3. Relative humidity:
    - a. 5 percent to 95 percent.



4. Audible noise:
  - a. Less than 45 dBa at 5 feet (1.5 m).
5. Operating altitude:
  - a. Zero to 12,000 feet above sea level.

- E. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B and C3 environments, as tested to IEEE C62.45.

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS**

- A. Enclosure:
  1. Located in electrical equipment as indicated on the Drawings.
  2. External mounting:
    - a. NEMA Type 4X enclosure:
      - 1) No ventilation openings.
    - b. Hinged cover requiring a tool for internal access.
    - c. Internal drawing pocket.
    - d. All monitoring indications must be visible without opening the door.
- B. Internal connections:
  1. Provide low impedance copper plates for intra-unit connections:
    - a. Attach surge modules using bolted connections to the plates for low impedance connections.
  2. Size all connections, conductors, and terminals for the specified surge current capacity.
- C. Surge diversion modules:
  1. MOV:
    - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent protection:
  1. Individually fuse all components, including suppression, filtering, and monitoring components:
    - a. Rated to allow maximum specified nominal discharge current capacity.
    - b. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections:
  1. Provide terminals to accommodate wire sizes up to #2 AWG.

## **2.08 ACCESSORIES**

- A. Unit status indicators:
  1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
    - a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
    - b. Indicates the status of protection on each mode or phase.





- B. Dry contacts for remote monitoring:
  - 1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.
- C. Provide an audible alarm which activates under any fault condition.
  - 1. Provide an alarm On/Off switch to silence the alarm.
  - 2. A visible LED will confirm whether alarm is On or Disabled.
  - 3. Locate both switches and the audible alarm on the unit's front cover.
- D. Provide an integral disconnect switch located in-line with the SPD enclosure:
  - 1. External manual operator.
  - 2. The switch shall disconnect all ungrounded circuit conductors from the SPD.
  - 3. The integral disconnect switch shall be capable of withstanding, without failure, the maximum published surge current magnitude and short circuit current without failure or damage to the switch.
- E. Interconnection cable:
  - 1. Interconnect the SPD to the power system using a manufacturer furnished assembly of low impedance coaxial cables installed in flexible conduit.
  - 2. Cable designed to transmit transients with minimal voltage drop.
  - 3. UL listed.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL**

- A. Permanently affix surge rating to the SPD.
- B. Perform manufacturer's standard factory test:
  - 1. Perform testing in accordance with UL 1449.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.
- C. Special techniques:
  - 1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
    - a. Twist the input conductors together to reduce input conductor inductance.



2. Interconnect the SPD to the power system using a manufacturer supplied interconnection cable consisting of low impedance coaxial cables installed in a flexible conduit.
3. Do not subject SPD to insulation resistance testing.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16950 - Field Electrical Acceptance Tests.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16411

### DISCONNECT SWITCHES

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Fusible and non-fusible disconnect switches.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electric Manufacturer's Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment.
  - 2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. Underwriters Laboratories Inc. (UL):
  - 1. 20 - General-Use Snap Switches.
  - 2. 98 - Enclosed and Dead-Front Switches.
  - 3. 508 - Standard for Industrial Control Equipment.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
  - 1. Safety switches and disconnect switches are to be considered synonymous.

##### **1.04 SYSTEM DESCRIPTION**

- A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.
- B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer.
  - 2. Manufacturer's specifications and description.
  - 3. Ratings:
    - a. Voltage.
    - b. Current.



- c. Horsepower.
    - d. Short circuit rating.
  - 4. Fused or non-fused.
  - 5. NEMA enclosure type.
  - 6. Dimensions:
    - a. Height.
    - b. Width.
    - c. Depth.
  - 7. Weight.
  - 8. Cross-referenced to the disconnect schedule indicated on the Drawings.
- C. Shop drawings:
  - 1. Manufacturer's installation instructions:
    - a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
    - b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
  - 2. Identify motor or equipment served by each switch; indicate nameplate inscription.
- D. Installation instructions:
  - 1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 - Common Work Results for Electrical and calculations:
    - a. Stamped by a professional engineer registered in the state where the Project is being constructed.

## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
  - 1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
  - 2. UL 98 - Enclosed and Dead-Front Switches.
- C. Disconnect switches shall be UL listed and labeled.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING**

- A. After successful review of the initial fault current study, submit complete equipment submittal.



## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
1. Schneider Electric.
  2. Eaton.
  3. General Electric.
  4. Siemens.
  5. Appleton.
  6. Crouse-Hinds.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**

## **2.05 EQUIPMENT**

- A. Switch mechanism:
1. Quick-make, quick-break heavy-duty operating mechanisms:
    - a. Provisions for padlocking the switch in the Off position.
    - b. A minimum of 90-degree handle travel position between Off and On positions:
      - 1) Provide handle position indicators to identify the handle position.
    - c. Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
      - 1) With an externally operated override.
- B. Switch interior:
1. Switch blades visible when the switch is Off and the cover is open.
  2. Lugs:
    - a. Front accessible.
    - b. Removable.
    - c. UL listed for 60/75-degree Celsius copper conductors.
  3. Current carrying parts completely plated to resist corrosion.
  4. Removable arc suppressors to facilitate easy access to line side lugs.



5. Furnish equipment ground kits for every switch.
- C. Fused switches:
  1. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
    - a. Ratings 100 amperes through 600 amperes at 240 volts.
    - b. Ratings 30 amperes through 600 amperes at 600 volts.
    - c. Provide spring reinforced and plated fuse clips.
- D. Ratings:
  1. UL horsepower rated for AC or DC with the rating not less than the load served.
  2. Current:
    - a. 30 to 1,200 amperes.
  3. Voltage:
    - a. 250 volts AC, DC.
    - b. 600 volts (30 A to 200 A, 600 volts DC).
  4. Poles:
    - a. 2, 3, 4, and 6 poles.
  5. UL listed short circuit ratings:
    - a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
    - b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
    - c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
  6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.
- E. Size, fusing and number poles as indicated on the Drawings or as required:
  1. Provide solid neutral where indicated on the Drawings.

## **2.06 COMPONENTS (NOT USED)**

## **2.07 ACCESSORIES**

- A. Disconnect switches to have provisions for a field installable "B" type electrical interlock for position indication as indicated on the Drawings.
- B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.
- C. NEMA Type 7 and 9 enclosures furnished with drain and breather kit when used in outdoor applications.





**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL (NOT USED)**

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**

**3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
  - 1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
  - 2. Provide all mounting brackets, stands, supports and hardware as required:
    - a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
    - b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
  - 3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
    - a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
    - b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
  - 4. Provide a nameplate for each disconnect switch:
    - a. Provide per requirements specified in Section 16075 - Identification for Electrical Systems.
    - b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.



**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16412

### LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Low voltage molded case circuit breakers.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electrical Manufacturers Association (NEMA):
  - 1. AB 3. - Molded Case Circuit Breakers and Their Application.
- C. Underwriter's Laboratories (UL):
  - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
  - 2. 943 - Ground Fault Circuit Interrupters.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. In accordance with UL 489.

##### 1.04 SYSTEM DESCRIPTION

- A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Catalog cut sheets.
  - 2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

##### 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Low voltage molded case circuit breakers shall be UL listed and labeled.



## **1.07 DELIVERY, STORAGE AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
1. Eaton.
  2. General Electric Co.
  3. Schneider Electric.
  4. ABB.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS**

- A. General:
1. Conforming to UL 489.
  2. Operating mechanism:
    - a. Quick-make, quick-break, non-welding silver alloy contacts.
    - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
    - c. Mechanically trip free from the handle.
    - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
    - e. Lockable in the "OFF" position.



3. Arc extinction:
  - a. In arc chutes.
4. Voltage and current ratings:
  - a. Minimum ratings as indicated on the Drawings.
  - b. Minimum frame size 100A.
5. Interrupting ratings:
  - a. Minimum ratings as indicated on the Drawings.
  - b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

- B. Motor circuit protectors:
  1. Instantaneous only circuit breaker as part of a listed combination motor controller.
  2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS**

- A. Terminals:
  1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.
- B. Case:
  1. Molded polyester glass reinforced.
  2. Ratings clearly marked.
- C. Trip units:
  1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
  2. Thermal magnetic:
    - a. Instantaneous short circuit protection.
    - b. Inverse time delay overload.
    - c. Ambient or enclosure compensated by means of a bimetallic element.
  3. Solid state:
    - a. With the following settings as indicated on the Drawings.
      - 1) Adjustable long time current setting.
      - 2) Adjustable long time delay.
      - 3) Adjustable short time pickup.
      - 4) Adjustable short time delay.
      - 5) Adjustable instantaneous pickup.
      - 6) Adjustable ground fault pickup as indicated on the Drawings.
      - 7) Adjustable ground fault delay as indicated on the Drawings.
- D. Molded case circuit breakers for use in panelboards:
  1. Bolt-on type:
    - a. Plug-in type breakers are not acceptable.
  2. Ground fault trip devices as indicated on the Drawings.



**2.07 ACCESSORIES (NOT USED)**

**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL**

- A. Test breakers in accordance with:
  - 1. UL 489.
  - 2. Manufacturer's standard testing procedures.

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**

**3.03 INSTALLATION**

- A. Install breakers to correspond to the accepted shop drawings.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING**

- A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.
- B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.



**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION







## **SECTION 16445**

### **PANELBOARDS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Panelboards serving feeder circuits and branch circuits.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Underwriter's Laboratories, Inc. (UL):
  - 1. 67 - Standard for Panelboards.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.04 SYSTEM DESCRIPTION**

- A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
  - 1. Service voltage and configuration as indicated on the panel schedules.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer of panelboard.
  - 2. Bill of material.
  - 3. Assembly ratings including:
    - a. Voltage.
    - b. Phase.
    - c. Continuous current.
    - d. Short circuit interrupting rating.
  - 4. NEMA enclosure type.
  - 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
  - 6. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
  - 7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
    - a. Manufacturer's statement of seismic qualification with substantiating test data.



- b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
  - 1. Drawings to contain:
    - a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
      - 1) Height.
      - 2) Length.
      - 3) Width.
    - b. Weight.
    - c. Anchoring locations.
    - d. Breaker layout drawing with dimensions:
      - 1) Location of the main, branches, solid neutral, and ground.
    - e. Conduit entry/exit locations:
      - 1) Identify all conduit entry/exit locations and restrictions.
    - f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Installation instructions:
  - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
  - 2. For equipment installed in structures designated as seismic design category A or B:
    - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
  - 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
    - b. Submit anchoring drawings with supporting calculations.
    - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operations and maintenance manual:
  - 1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
    - a. Including but not limited to:
      - 1) Instruction narratives and bulletins.
      - 2) Renewal parts lists.
      - 3) Time-current curves for all devices.
- F. Calculations:
  - 1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.



## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Panelboards shall be UL listed and labeled.
  - 1. Where indicated as service entrance equipment, panelboards shall be UL labeled and listed "Suitable for Service Entrance."

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Eaton.
  - 2. General Electric Co.
  - 3. Schneider Electric.
- B. Circuit breakers:
  - 1. Same manufacturer as the panelboard.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**



2.05

## EQUIPMENT

- A. Provide panelboards with:
  - 1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
  - 2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.
- B. Short circuit rating:
  - 1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
  - 2. Testing method in accordance with UL 67.
  - 3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
  - 4. Panelboards shall be fully rated.

## 2.06 COMPONENTS

- A. Enclosure:
  - 1. NEMA enclosure type as indicated on the Drawings.
    - a. Where not indicated on the Drawings, as specified in Section 16050 - Common Work Results for Electrical for the installed location.
  - 2. Minimum width: 20 inches.
  - 3. Gutter space in accordance with the NEC:
    - a. Minimum of 4 inches of gutter space.
  - 4. Dead-front, no live parts when the panelboard is in service.
  - 5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
  - 6. 4-piece front to provide ease of wiring access.
  - 7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
    - a. Minimum 2 keys per panelboard.
    - b. Key all panelboard locks alike.
  - 8. Circuit directory frame and card on the inside of the door.
  - 9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
  - 10. Outdoor locations: Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.
- B. Bus:
  - 1. General:
    - a. Tin-plated copper.
  - 2. Phase bus:
    - a. Full size and height without reduction.
    - b. Dimensions and temperature rise in accordance with UL 67:
      - 1) Limit current density to less than 1,000 amps per square inch.
    - c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
  - 3. Ground bus:
    - a. Copper, solidly bonded.



4. Neutral bus:
  - a. Provide where indicated on the Drawings.
  - b. 100 percent rated.
  - c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

- C. Lugs:
  1. UL listed for copper and aluminum wire:
    - a. Provide lugs rated for 75-degree Celsius terminations.
    - b. Provide bolted or compression main lug terminations as required for the incoming cable size.
- D. Circuit breakers: As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
  1. Provide all circuit breakers with bolt-on connections:
    - a. Plug-in circuit breakers are not allowed.

## **2.07 ACCESSORIES**

- A. Surge protective devices:
  1. Furnish panelboards with surge protective devices as indicated on the Drawings.
  2. As specified in Section 16285 - Surge Protective Devices.
- B. Nameplates:
  1. As specified in Section 16075 - Identification for Electrical Systems.
  2. Install on outside of door.
  3. Indicating:
    - a. Panel designation.
    - b. Voltage.
    - c. Number of phases and configuration.
- C. Circuit identification labels:
  1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
  2. Type all information on the cards using designations in the panel schedules.
  3. Laminated on both sides.
- D. Pad locking mechanism:
  1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
  2. At a minimum, provide 1 mechanism per panelboard:
    - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.



## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES**

- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.
- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

## **2.11 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
  - 1. Surface, flush or MCC mounted as indicated on the Drawings.
  - 2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
  - 3. Perform work in accordance with the manufacturer's instructions and shop drawings.
  - 4. Provide all brackets, hangers, supports, and hardware for mounting as required.
  - 5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
    - a. Use only stainless steel mounting hardware.
  - 6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

## **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

## **3.05 REPAIR/RESTORATION (NOT USED)**

## **3.06 RE-INSTALLATION (NOT USED)**





### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Factory testing:
  - 1. Perform standard factory tests on the panelboards:
  - 2. Test in accordance with the latest version of NEMA and UL standards.

### **3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.09 ADJUSTING (NOT USED)**

### **3.10 CLEANING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.12 SCHEDULES**

- A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.
- B. Provide typewritten schedule in each panelboard.

END OF SECTION





## SECTION 16950

### FIELD ELECTRICAL ACCEPTANCE TESTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Responsibilities for testing the electrical installation.
  - 2. Adjusting and calibration.
  - 3. Acceptance tests.
- B. Copyright information:
  - 1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American National Standards Institute (ANSI).
- C. ASTM International (ASTM):
  - 1. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
  - 2. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
  - 3. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
  - 4. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
  - 5. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
  - 6. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
  - 7. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
  - 8. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
  - 9. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
  - 10. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
  - 11. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
- D. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
  - 2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.



3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
  4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
  5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
  6. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
  7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
  8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
  9. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
  10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
  11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
- E. Insulated Cable Engineer's Association (ICEA).
- F. InterNational Electrical Testing Association (NETA).
1. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- G. International Electrotechnical Commission (IEC).
- H. Manufacturer's testing recommendations and instruction manuals.
- I. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
  2. 110 - Standard for Emergency and Standby Power Systems.
- J. National Institute of Standards and Technology (NIST).
- K. Specification sections for the electrical equipment being tested.
- L. Shop drawings.

### **1.03 DEFINITIONS**

- A. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.
- B. Specific definitions:
1. Testing laboratory: The organization performing acceptance tests.

### **1.04 SYSTEM DESCRIPTION**

- A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.



- B. Conduct all tests in the presence of the Engineer or the Engineer's representative.
  - 1. Engineer will witness all visual, mechanical, and electrical tests, and inspections.
- C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.
- D. Responsibilities:
  - 1. Contractor responsibilities:
    - a. Ensure that all resources are made available for testing, and that all testing requirements are met.
  - 2. Electrical subcontractor responsibilities:
    - a. Perform routine tests during installation.
    - b. Demonstrate operation of electrical equipment.
    - c. Commission the electrical installation.
    - d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
      - 1) Providing electrical power as required.
      - 2) Operating of electrical equipment in conjunction with testing of other equipment.
      - 3) Activating and shutting down electrical circuits.
      - 4) Making and recording electrical measurements.
      - 5) Replacing blown fuses.
      - 6) Installing temporary jumpers.
  - 3. Testing laboratory responsibilities:
    - a. Perform all acceptance tests specified in this Section.
    - b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

#### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. LAN cable test form:
  - 1. LAN cable test reports:
    - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
      - 1) Test type.
      - 2) Test location.
      - 3) Test date.
      - 4) Cable number.
      - 5) Cable length.
      - 6) Certification that the cable meets or exceeds the specified standard.
    - b. Furnish hard copy and electronic copy for all traces.
- C. Manufacturers' testing procedures:
  - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.



D. Test report:

1. Include the following:
  - a. Summary of Project.
  - b. Description of equipment tested.
  - c. Description of tests performed.
  - d. Test results.
  - e. Conclusions and recommendations.
  - f. Completed test forms.
  - g. List of test equipment used and calibration dates.
  - h. LAN cable test reports.

E. Test data records:

1. Include the following:
  - a. Identification of the testing organization.
  - b. Equipment identification.
  - c. Nameplate data.
  - d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
  - e. Dates of inspections, tests, maintenance and or calibrations.
  - f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
  - g. Expected results when calibrations are to be performed.
  - h. Indication of as-found and as-left results as applicable.
  - i. Indication of all test results outside specified tolerances.

F. Testing laboratory qualifications:

1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
  - a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
    - 1) Corporate history and references.
    - 2) Resume of individual performing test.
    - 3) Equipment list and test calibration data.

G. Division of responsibilities:

1. Submit a list identifying who is responsible for performing each portion of the testing.

## 1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Testing laboratory qualifications:

1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

## 1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)



## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING**

- A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.
- B. Perform testing in the following sequence:
  - 1. Perform routine tests as the equipment is installed including:
    - a. Insulation-resistance tests.
    - b. Continuity tests.
    - c. Rotational tests.
  - 2. Adjusting and preliminary calibration.
  - 3. Acceptance tests.
  - 4. Demonstration.
  - 5. Commissioning and plant start-up.

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP (NOT USED)**

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION**

- A. Test instrument calibration:
  - 1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
    - a. The calibrating standard shall be of better accuracy than that of the equipment tested.
  - 2. The accuracy shall be traceable to the NIST in an unbroken chain.
  - 3. Calibrate instruments in accordance with the following frequency schedule:
    - a. Field instruments: 6 months maximum.
    - b. Laboratory instruments: 12 months maximum.





- c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
  - 4. Dated calibration labels shall be visible on all test equipment.
  - 5. Maintain an up-to-date instrument calibration record for each test instrument:
    - a. The records shall show the date and results of each calibration or test.
  - 6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
- B. Do not begin testing until the following conditions have been met:
  - 1. All instruments required are available and in proper operating condition.
  - 2. All required dispensable materials such as solvents, rags, and brushes are available.
  - 3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
  - 4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
  - 5. Data sheets to record all test results are available.

### **3.03 INSTALLATION**

- A. Test decal:
  - 1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
  - 2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
    - a. White: electrically and mechanically acceptable.
    - b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
  - 3. The decal shall include the following information at a minimum:
    - a. Testing organization.
    - b. Project identifier.
    - c. Test date.
    - d. Technician identifier.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Testing and Training Phase: Installation Testing:
  - 1. Also called "Field Acceptance Testing".
  - 2. Panelboards:
    - a. Cleaning:
      - 1) Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.



- 2) Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
  - 3) Avoid blowing dust into panelboards. Do not use a blower or compressed air.
  - 4) Clean Supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
  - 5) Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
- b. General:
- 1) Compare equipment nameplate data with the Contract Documents.
  - 2) Check panelboard circuit schedule for accuracy.
  - 3) Verify appropriate anchorage, required area clearances, and correct alignment.
  - 4) Inspect overall general condition for physical damage. Check for broken studs and loose or damaged wires, connector, terminations, etc. Check all bolts, nuts, washer, and pins for tightness. Tighten or use manufacture's replacement parts as required.
  - 5) Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
  - 6) Check that covers are in place and fastened. Plug any open unused knockouts.
  - 7) Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect all component devices. Replace any components that show evidence of damage from moisture.
  - 8) Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
  - 9) Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking. Investigate and correct sources of arcing or overheating. Consult the panelboard manufacturer for recommendations.
  - 10) Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breaker's address for microprocessor communications packages, if equipped.
  - 11) Set adjustable circuit breakers in accordance with engineering coordination study supplied by **Owner**.
- c. Terminations, Connections, and Lugs:
- 1) Inspect bolted electrical connections for high resistance using one of the following methods:
    - a) Use of low-resistance ohmmeter.
      - (1) Compare bolted connection resistance values to values of similar connections:
        - (a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.



- b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
  - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
  - 2) Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
  - 3) Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
  - 4) Replace overheated connections. Tighten connections to proper to proper torque levels as specified above.
- d. Conductors and raceways:
  - 1) Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
  - 2) Ensure the conductors are protected within their ampacities.
  - 3) Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
  - 4) Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with manufacturer's recommendations.
  - 5) Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
  - 6) Inspect for frayed or broken wires. Replace or repair conductors as necessary.
  - 7) Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.
- e. Circuit breakers:
  - 1) Breakers rated less than 100 A:
    - a) Operate circuit breakers several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
    - b) Visually check circuit breakers for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
    - c) Check circuit breakers for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
    - d) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
    - e) Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
    - f) Check circuit breaker terminals and connections for tightness as specified above.
  - 2) Breakers rated 100 A and higher:
    - a) Perform visual and mechanical inspection as specified in this Section.
    - b) Perform electrical tests as specified in this Section.



3. Dry type transformers:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Verify that resilient mounts are free and that any shipping brackets have been removed.
    - 5) Inspect equipment for cleanliness.
    - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 7) Verify that as-left tap connections are as specified.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
      - a) Apply voltage in accordance with manufacturer's published data.
        - (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Calculate dielectric absorption ration or polarization index.
    - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
  - c. Test values:
    - 1) Compare bolted connection resistance values to values of similar connections:
      - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Tap connections are left as found unless otherwise specified.
    - 4) Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
      - b) Investigate insulation values less than the allowable minimum.
    - 5) The dielectric absorption ratio or polarization index shall not be less than 1.0.
    - 6) Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
    - 7) Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.
4. Low voltage cables, 600 volt maximum:
  - a. Visual and mechanical inspection:
    - 1) Compare cable data with the Drawings and Specifications.



- 2) Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
- 3) Inspect bolted electrical connections for high resistance by one of the following methods:
  - a) Use of low-resistance ohmmeter.
  - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
    - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- 4) Inspect compression applied connectors for correct cable match and indentation.
- 5) Inspect for correct identification and arrangement.
- 6) Inspect cable jacket insulation and condition.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
    - a) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
    - b) Test duration shall be 1 minute.
  - 3) Perform continuity tests to insure correct cable connection.
  - 4) Verify uniform resistance of parallel conductors.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate values of insulation-resistance less than the allowable minimum.
  - 3) Cable shall exhibit continuity.
  - 4) Deviations in resistance between parallel conductors shall be investigated.
5. Low voltage molded case and insulated case circuit breakers:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage and alignment.
    - 4) Verify the unit is clean.
    - 5) Operate the circuit breaker to ensure smooth operation.
    - 6) Inspect bolted electrical connections for high resistance by one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.



- 7) Perform adjustments for final protective device settings in accordance with the coordination study.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
    - a) Apply voltage in accordance with manufacturer's published data.
    - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Perform a contact/pole-resistance test.
  - 4) Determine long-time pickup and delay by primary current injection.
  - 5) Determine short-time pickup and delay by primary current injection.
  - 6) Determine ground-fault pickup and delay by primary current injection.
  - 7) Determine instantaneous pickup value by primary current injection.
  - 8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
  - 9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
    - a) Reset all trip logs and indicators.
  - 10) Verify operation of charging mechanism.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate values of insulation-resistance less than the allowable minimum.
  - 4) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
    - a) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
  - 5) Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
    - a) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
  - 6) Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.





- 7) Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
  - 8) Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 9) Pickup values and trip characteristics shall be within manufacturer's published tolerances.
  - 10) Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
  - 11) The charging mechanism shall operate in accordance with manufacturer's published data.
6. Instrument transformers - current transformers:
- a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Verify correct connection of transformers with system requirements.
    - 4) Verify that adequate clearances exist between primary and secondary circuit wiring.
    - 5) Verify the unit is clean.
    - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 7) Verify that all required grounding and shorting connections provide contact.
    - 8) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
      - a) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
    - 3) Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
    - 4) Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
    - 5) Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
    - 6) Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
    - 7) When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:
      - a) Test voltages shall be in accordance with NETA ATS tables.
    - 8) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.





- 9) Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
  - a) That grounding point should be located as specified by the Engineer in the Contract Documents.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 4) Polarity results shall agree with transformer markings.
  - 5) Ratio errors shall be in accordance with IEEE C57.13.
  - 6) Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
  - 7) Measured burdens shall be compared to instrument transformer ratings.
  - 8) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
  - 9) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
    - a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.
  - 10) Test results shall indicate that the circuits have only 1 grounding point.
7. Instrument transformers - voltage transformers:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Verify correct connection of transformers with system requirements.
    - 4) Verify that adequate clearances exist between primary and secondary circuit wiring.
    - 5) Verify the unit is clean.
    - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 7) Verify that all required grounding and connections provide contact.
    - 8) Verify correct primary and secondary fuse sizes for voltage transformers.



- 9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- 10) Perform as-left tests.
- b. Electrical tests - voltage transformers:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation-resistance tests winding-to-winding and winding-to-ground:
    - a) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
    - b) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
  - 3) Perform a polarity test on each voltage transformer to verify the polarity marks on H<sub>1</sub>- X<sub>1</sub> relationship as applicable.
  - 4) Perform a turns ratio test on all tap positions.
  - 5) Measure voltage circuit burdens at transformer terminals.
  - 6) Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
    - a) The dielectric voltage shall be in accordance with NETA ATS tables.
    - b) Apply the test voltage for 1 minute.
  - 7) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
  - 8) Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
    - a) That grounding point should be located as specified by the Engineer in the Contract Documents.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 4) Polarity results shall agree with transformer markings.
  - 5) Ratio errors shall be in accordance with IEEE C57.13.
  - 6) Measured burdens shall be compared to instrument transformer ratings.
  - 7) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
  - 8) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
    - a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.



- 9) Test results shall indicate that the circuits have only 1 grounding point.
8. Metering devices, microprocessor based:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect meters and cases for physical damage.
    - 3) Clean front panel.
    - 4) Verify tightness of electrical connections.
    - 5) Record the following:
      - a) Model number.
      - b) Serial number.
      - c) Firmware revision.
      - d) Software revision.
      - e) Rated control voltage.
    - 6) Verify operation of display and indicating devices.
    - 7) Record passwords.
    - 8) Verify the unit is grounded in accordance with the manufacturer's instructions.
    - 9) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
  - b. Electrical tests:
    - 1) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
    - 2) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital and analog.
    - 3) After initial system energization, confirm measurements and indications are consistent with loads present.
  - c. Test values:
    - 1) Nameplate data shall match the Contract Documents.
    - 2) Tightness of electrical connections shall ensure a low resistance connection.
    - 3) Display and indicating devices shall operate per manufacturer's published data.
    - 4) Measurement and indication of applied voltages and currents shall be within the manufacturer's published tolerances for accuracy.
    - 5) All auxiliary input/output features shall operate per settings and manufacturer's published data.
    - 6) Measure and indications shall be consistent with energized system loads.
9. Grounding systems:
  - a. Visual and mechanical inspection:
    - 1) Inspect ground system for compliance with the Contract Documents, and the NEC.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.



- 4) Inspect anchorage.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
    - 3) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
  - c. Test values:
    - 1) Grounding system electrical and mechanical connections shall be free of corrosion.
    - 2) Compare bolted connection resistance values to values of similar connections:
      - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 3) Bolt-torque levels shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 4) The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding.
    - 5) Investigate point-to-point resistance values that exceed 0.5 ohm.
10. Rotating machinery, ac induction motors and generators:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate information with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging
    - 5) Inspect bolted electrical connections for high resistance using one or more of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 6) Verify correct application of appropriate lubrication and lubrication systems.
    - 7) Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
  - b. Electrical tests - AC Induction:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform insulation-resistance test in accordance with IEEE 43:
      - a) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30 second periods.
      - b) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.



- 3) On machines rated at 2,300 volts and greater, perform dielectric withstand voltage tests in accordance with:
  - a) IEEE 95 for dc dielectric withstand voltage tests.
  - b) NEMA MG1 for ac dielectric withstand voltage tests.
- 4) Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
- 5) Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.
- 6) Test surge protection devices as specified in this Section.
- 7) Test motor starter as specified in this Section.
- 8) Perform resistance tests on resistance temperature detector (RTD) circuits.
- 9) Verify operation of motor space heater, if applicable.
- c. Test values:
  - 1) Inspection:
    - a) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
    - b) Filter media shall be clean and installed in accordance with the manufacturer's published data.
    - c) Cooling fans shall operate.
    - d) Slip ring alignment shall be within manufacturer's published tolerances.
    - e) Brush alignment shall be within manufacturer's published tolerances.
    - f) Brush rigging shall be within manufacturer's published tolerances.
  - 2) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 3) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 4) Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
  - 5) The recommended minimum insulation-resistance ( $IR_{1 \min}$ ) test results in megohms shall be in accordance with NETA ATS tables.
    - a) The polarization index value shall not be less than 2.0.
    - b) The dielectric absorption ratio shall not be less than 1.4.
  - 6) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
  - 7) Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.
  - 8) Power factor or dissipation factor values shall be compared to manufacturer's published data:
    - a) In the absence of manufacturer's published data, compare values of similar machines.
  - 9) Tip-up values shall indicate no significant increase in power factor.



- 10) If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
- 11) Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
  - a) In the absence of manufacturer's published data, compare values of similar machines.
- 12) Test results of surge protection devices shall be as specified in this Section.
- 13) Test results of motor starter equipment shall be as specified in this Section.
- 14) RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
- 15) Heaters shall be operational.
- 16) Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with manufacturer's published data:
  - a) In the absence of manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
  - b) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
11. Motor starters, low voltage:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate information with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Verify the unit is clean.
    - 5) Inspect contactors:
      - a) Verify mechanical operation.
      - b) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer's published data.
    - 6) Motor-running protection:
      - a) Verify overload element rating/motor protection settings are correct for its application.
      - b) If motor running protection is provided by fuses, verify correct fuse rating.
    - 7) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 8) Lubrication requirements:
      - a) Verify appropriate lubrication on moving current-carrying parts.
      - b) Verify appropriate lubrication on moving and sliding surfaces.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.





- 2) Perform insulation-resistance tests for 1 minute on each pole, phase to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
  - a) Test voltage shall be in accordance with manufacturer's published data.
  - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
- 3) Test motor protection devices in accordance with manufacturer's published data.
- 4) Test circuit breakers as specified in this Section.
- 5) Perform operational tests by initiating control devices.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate values of insulation-resistance less than the allowable minimum.
  - 4) Motor protection parameters shall be in accordance with manufacturer's published data.
  - 5) Circuit breaker test results shall as specified in this Section.
  - 6) Control devices shall perform in accordance with system design requirements.
12. Motor control centers, low voltage:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, grounding and required clearances.
    - 4) Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
    - 5) Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
    - 6) Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
    - 7) Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
    - 8) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.





- 9) Verify operation and sequencing of interlocking systems:
  - a) Attempt closure on locked-open devices.
  - b) Attempt to open locked-closed devices.
  - c) Make/attempt key-exchanges in all positions.
- 10) Lubrication requirements:
  - a) Verify appropriate lubrication on moving current-carrying parts.
  - b) Verify appropriate lubrication on moving and sliding surfaces.
- 11) Inspect insulators for evidence of physical damage or contaminated surfaces.
- 12) Verify correct barrier and shutter installation and operation.
- 13) Exercise all active components.
- 14) Inspect all indicating devices for correct operation.
- 15) Verify that filters are in place and/or vents are clear.
- 16) Perform visual and mechanical inspection of instrument transformers as specified in this Section.
- 17) Perform visual and mechanical inspection of surge arresters as specified in this Section.
- 18) Inspect control power transformers:
  - a) Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.
  - b) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
  - c) Verify correction functioning of grounding contacts.
- 19) Perform visual and mechanical inspection of all motor control center components as specified in this Section.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
    - a) Perform test in accordance with NETA ATS tables.
  - 3) Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
  - 4) Perform ground-resistance tests:
    - a) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
  - 5) Control power transformers:
    - a) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
      - (1) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
    - b) Perform secondary wiring integrity test:
      - (1) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
        - (a) Verify correct potential at all devices.



- c) Verify correct secondary voltage by energizing primary winding with system voltage:
        - (1) Measure secondary voltage with the secondary wiring disconnected.
    - 6) Verify operation of space heaters.
    - 7) Perform electrical tests of all motor control center components as specified in this Section.
  - c. Test values:
    - 1) Compare bolted connection resistance values to values of similar connections:
      - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
      - b) Investigate insulation values less than the allowable minimum.
      - c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
    - 4) Bus insulation shall withstand the over potential test voltage applied.
    - 5) Instrument transformer test values shall be as specified in this Section.
    - 6) Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
    - 7) Meter accuracy shall be in accordance with manufacturer's published data.
    - 8) Control power transformers:
      - a) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:
        - (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        - (2) Investigate insulation values less than the allowable minimum.
        - (3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
      - b) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
      - c) Secondary voltage shall be as indicated on the Drawings.
    - 9) Heaters shall be operational.
    - 10) Test values for motor control center components shall be as specified in this Section.
13. Variable frequency drive systems:
- a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Verify the unit is clean.



- 5) Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
- 6) Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
- 7) Motor running protection:
  - a) Verify drive overcurrent setpoints are correct for their application.
  - b) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
  - c) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
- 8) Inspect bolted electrical connections for high resistance using one of the following methods:
  - a) Use of low-resistance ohmmeter.
  - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
    - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- 9) Verify correct fuse sizing in accordance with manufacturer's published data.
- 10) Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with low resistance ohmmeter.
  - 2) Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
  - 3) Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS or as recommended by the manufacturer:
    - a) Input phase loss protection.
    - b) Input overvoltage protection.
    - c) Output phase rotation.
    - d) Overtemperature protection.
    - e) Direct current overvoltage protection.
    - f) Overfrequency protection.
    - g) Drive overload protection.
    - h) Fault alarm outputs.
  - 4) Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
  - 5) Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
  - 6) Perform operational tests by initiating control devices:
    - a) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
    - b) Verify operation of drive from remote start/stop and speed control signals.
  - 7) Perform electrical tests of input circuit breaker as specified in this Section.
  - 8) Measure fuse resistance.



- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
  - 4) Test values for input circuit breaker shall be as specified in this Section.
  - 5) Relay calibration results shall be as specified in this Section.
  - 6) Continuity of bonding conductors shall be in accordance with NETA ATS.
  - 7) Control devices shall perform in accordance with system requirements.
  - 8) Operational tests shall conform to system design requirements.
  - 9) Investigate fuse resistance values that deviate from each other by more than 15 percent.
- 14. Surge arresters, low-voltage:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, grounding, and clearances.
    - 4) Verify the arresters are clean.
    - 5) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
    - 7) Verify that stroke counter is correctly mounted and electrically connected, if applicable.
    - 8) Record stroke counter reading.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
      - a) Apply voltage in accordance with manufacturers published data.
      - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Test grounding connection as specified in this Section.



- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate insulation values less than the allowable minimum.
  - 4) Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
- 15. Fiber-optic cables:
  - a. Visual and mechanical inspection:
    - 1) Compare cable, connector, and splice data with the Contract Documents.
    - 2) Inspect cable and connections for physical and mechanical damage.
    - 3) Verify that all connectors and splices are correctly installed.
  - b. Optical tests:
    - 1) Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
      - a) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
      - b) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
    - 2) Perform connector and splice integrity test using an optical time domain reflectometer.
    - 3) Perform cable attenuation loss measurement with an optical power loss test set:
      - a) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
      - b) Test multimode fibers at 850 nanometer and 1,300 nanometer.
      - c) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
    - 4) Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
      - a) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
    - 5) Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
      - a) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.



- b) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
- c. Test values:
  - 1) Cable and connections shall not have been subjected to physical or mechanical damage.
  - 2) Connectors and splices shall be installed in accordance with industry standards.
  - 3) The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
  - 4) Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
  - 5) Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

### **3.08 FIELD QUALITY CONTROL (NOT USED)**

### **3.09 ADJUSTING (NOT USED)**

### **3.10 CLEANING**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

### **3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17050

### COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. General requirements applicable to all Process Control and Instrumentation Work.
  - 2. General requirements for process control and instrumentation submittals.
  - 3. As specified in this Section, some SCADA/HMI software configuration will be provided by the Owner. **SPECIFICALLY, THE HMI CONFIGURATION WILL BE BY OWNER, ALL OTHER PROGRAMMING AND INTEGRATION SHALL BE BY CONTRACTOR.**
- B. Interfaces to equipment, instruments, and other components:
  - 1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
  - 2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
    - a. Make all changes necessary to meet the manufacturer's wiring requirements.
  - 3. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation, control systems, and related services are provided. Include any items indicated on the Drawings or in Specifications from other disciplines in the scope of Work.
  - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
    - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
  - 5. Loop drawings:
    - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
    - b. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.



- C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
  2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
- D. Contract Documents:
1. General:
    - a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
  2. Specifications:
    - a. Documents 00700 - General Conditions and 00712 - Supplementary Conditions of the Contract Documents govern the Work.
    - b. These requirements are in addition to all General Requirements.
  3. Contract drawings:
    - a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
    - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
      - 1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
      - 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
  - c. Installation details:
    - 1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
  - d. Schematic diagrams:
    - 1) All controls are shown de-energized.



- 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
- 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
- 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
- 5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:

1. Substitute item provisions as specified in Document 00700 - General Conditions.

F. Changes and change orders:

1. As specified in Section 01600 - Product Requirements.

## 1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01410 - Regulatory Requirements:
  - a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
2. The following codes and standards are hereby incorporated into this Section:
  - a. American National Standards Institute (ANSI).
  - b. American Petroleum Institute (API):
    - 1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
    - 2) RP 551 - Process Measurement Instrumentation.
  - c. International Organization for Standardization (ISO):
    - 1) 9001 - Quality Management Systems - Requirements.
  - d. International Society of Automation (ISA):
    - 1) 5.1 - Instrumentation Symbols and Identification.
    - 2) 5.4 - Instrument Loop Diagrams.
    - 3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
  - e. National Electrical Manufacturers Association (NEMA):
    - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
  - f. National Fire Protection Association (NFPA).
  - g. National Institute of Standards and Technology (NIST).
  - h. Underwriters Laboratories, Inc. (UL):
    - 1) 508 - Standard of Safety for Industrial Control Equipment.
    - 2) 508A - Standard of Safety for Industrial Control Panels.



- B. Compliance with Laws and Regulations:
1. As specified in Document 00700 - General Conditions.

### 1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
1. Factory Mutual (FM).
  2. International Electrotechnical Commission (IEC).
  3. Institute of Electrical and Electronics Engineers (IEEE).
  4. International Society of Automation (ISA).
  5. International Organization for Standardization (ISO).
  6. National Electrical Code (NEC).
  7. National Electrical Manufacturers Association (NEMA).
  8. InterNational Electrical Testing Association (NETA).
  9. National Fire Protection Association (NFPA).
  10. National Institute of Standards and Technology (NIST).
  11. Underwriters Laboratories (UL).
- B. Specific definitions:
1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
  2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
  3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
  4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
  5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
  6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
    - a. Fieldbus communications signal or both.
  7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
- C. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
  2. Type 2 enclosure in accordance with NEMA 250.
  3. Type 3 enclosure in accordance with NEMA 250.
  4. Type 3R enclosure in accordance with NEMA 250.
  5. Type 3S enclosure in accordance with NEMA 250.



6. Type 3X enclosure in accordance with NEMA 250.
7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 12 enclosure in accordance with NEMA 250.
15. Type 12K enclosure in accordance with NEMA 250.
16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:

1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.
3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
4. DPDT: Double-pole, double-throw.
5. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
6. FAT: Factory acceptance test also known as Source Test.
7. HART: Highway addressable remote transducer.
8. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
10. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
11. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
12. I/O: Input/Output.
13. IP: Internet protocol or ingress protection.
14. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.



16. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
17. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
18. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
19. P&ID: Process and instrumentation diagram.
20. PC: Personal computer.
21. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
22. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
23. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCS/LCPs, VCPs and all data management systems accessible to staff.
24. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SPDT: Single-pole, double-throw.
31. SPST: Single-pole, single-throw.
32. UPS: Uninterruptible power supply.
33. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
34. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.





## 1.04 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.
- B. General:
  - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
  - 2. Furnish the submittals required by each section in the Instrumentation Specifications.
  - 3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
    - a. Uniquely number each wire.
    - b. Wire numbers must appear on all Equipment Drawings.
  - 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Submittal organization:
  - 1. First page:
    - a. Specification section reference.
    - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
    - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
    - d. Comments.
    - e. Contractor's review certification statement and signature.
  - 2. Next pages:
    - a. Provide confirmation of specification compliance:
      - 1) Specification section: Include with each submittal a copy of the relevant specification section.
        - a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
        - b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
    - b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
      - 1) In the order that the comments or questions were presented throughout the submittal.
      - 2) Referenced by index section and page number on which the comment appeared.
      - 3) Acceptable responses to Engineer's comments are either:
        - a) Engineer's comment or change is accepted and appropriate changes are made.
        - b) Explain why comment is not accepted or requested change is not made.
        - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
      - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
      - 5) No further review by the Engineer will be performed until a response for previous comments has been received.





3. Remaining pages:
  - a. Actual submittal data:
    - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
    - 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.
- D. Submittal requirements:
  1. Furnish submittals that are fully indexed with a tabbed divider for every component.
  2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
  3. Furnish submittals in the following general order, each in a separate bound set:
    - a. Schedule of Values.
    - b. Product Data.
    - c. After Engineer acceptance of the Product Data, submit the Project Shop Drawing submittals.
    - d. Loop Description Submittal.
    - e. The Process Control Hardware and Software Submittal including, control system software, programming, and screens.
    - f. Testing, Calibration and Process Start-Up procedures.
    - g. Operation and Maintenance Data.
    - h. Training Submittals.
    - i. Record Documents.
  4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
    - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
  5. Submit copies of shop drawings, and product data:
    - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
  6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
    - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
  7. Exceptions to Specifications and Drawings:
    - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
    - c. Acceptance of any exception is at the sole discretion of the Engineer.



- 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
- d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

E. Submittal preparation:

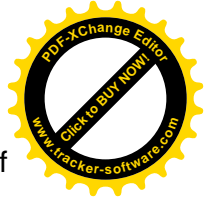
1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
  - a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
  - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

F. Specific submittal requirements:

1. Shop drawings:
  - a. Required for materials and equipment listed in this and other sections.
  - b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
  - c. Shop drawings requirements:
    - 1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
    - 2) Locations of conduit entrances and access plates.
    - 3) Component layout and identification.
    - 4) Schematic and wiring diagrams with wire numbers and terminal identification.
    - 5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
    - 6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
    - 7) Weight.
    - 8) Finish.
    - 9) Nameplates:
      - a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
    - 10) Temperature limitations, as applicable.



- d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
  - e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
    - 1) Uniquely number each wire per the Specifications.
  - f. Wire numbers must appear on all equipment drawings.
  - g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
    - 1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
    - 2) Binder ring size: 2 inches.
  - h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
    - 1) The firm's registered business name.
    - 2) Firm's physical address, email address, and phone number.
    - 3) Owner's name.
    - 4) Project name and location.
    - 5) Drawing name.
    - 6) Revision level.
    - 7) Personnel responsible for the content of the drawing.
    - 8) Date.
  - i. The work includes modifications to existing circuits:
    - 1) Clearly show all modifications to existing circuits.
    - 2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
2. Product data:
- a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
  - b. Include:
    - 1) Catalog cuts.
    - 2) Bulletins.
    - 3) Brochures.
    - 4) Quality photocopies of applicable pages from these documents.
    - 5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
    - 6) Identify model number and options for the actual equipment being furnished.
    - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
  - c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
  - d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
    - 1) Uniquely number each wire per the Specifications.
  - e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
- a. As specified in Section 01782 - Operation and Maintenance Data.



- b. Submit preliminary sets of these manuals to the Engineer for review of format and content:
  - 1) Engineer will return 1 set with comments.
  - 2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Functional Testing of the systems.
- c. Incorporate changes that occur during process start-up and submit as part of the final manuals.
- d. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
- e. Include Record Documents and the accepted shop drawing submittals, modified for conditions encountered in the field during the work.
- f. Include signed results from Functional Testing and Process Operational Period.
- g. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
- h. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
- i. Spare parts list:
  - 1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
    - a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
  - 2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
- j. Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
- k. Additional operation and maintenance manual requirements:
  - 1) Completely index manuals with a tab for each section:
    - a) Each section containing applicable data for each piece of equipment, system, or topic covered.
    - b) Assemble manuals using the accepted shop drawings, and include, the following types of data:
      - (1) Complete set of 11-inch by 17-inch drawings of equipment.
      - (2) Complete set of 11-inch by 17-inch drawings of the control system.
      - (3) Complete set of control schematics.
      - (4) Complete parts list for all equipment being provided.
      - (5) Catalog data for all products or equipment furnished.
- l. Operational Manual:
  - 1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
- m. Control System Software Record Documents:
  - 1) Include complete documentation of all the software programs provided for the entire control and PCS system, including:
    - a) Listings of all application software on both hard copy and DVD, DVD-ROM, and CD-ROM.



- b) Database, both hard copy and DVD, DVD-ROM, and CD-ROM.
    - c) Communication protocols.
    - d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
  - n. Organize the operation and maintenance manuals for each process in the following manner:
    - 1) Section A - Process and Instrumentation Diagrams.
    - 2) Section B - Control Descriptions.
    - 3) Section C - Loop Drawings.
    - 4) Section D - Instrument Summary.
    - 5) Section E - Instrument Data Sheets and Brochures.
    - 6) Section F - Sizing Calculations.
    - 7) Section G - Instrumentation Installation Details.
    - 8) Section H - Test Results.
    - 9) Section I - Operational Manual.
    - 10) Section J - Spare Parts List.
    - 11) Section K - Control System Software.
- 5. Material and equipment schedules:
  - a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
    - 1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- 6. Itemized instrument summary:
  - a. Submit a hard copy of the instrument summary.
  - b. List all of the key attributes of each instrument including:
    - 1) Tag number.
    - 2) Manufacturer.
    - 3) Model number.
    - 4) Service.
    - 5) Area location.
    - 6) Calibrated range.
    - 7) Loop drawing number.
  - c. Associated LCS/LCP, VCP, PCM, or PLC.
- 7. Instrument data sheets and cut sheets:
  - a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
    - 1) Component functional description specified in this Section and indicated on the Drawings.
    - 2) Manufacturers model number or other product designation.
    - 3) Tag number specified in this Section and indicated on the Drawings.
    - 4) System or loop of which the component is a part.
    - 5) Location or assembly at which the component is to be installed.
    - 6) Input and output characteristics, including digital bus communication.
    - 7) Scale range with units and multiplier.
    - 8) Requirements for electric supply.
    - 9) Requirements for air supply.



- 10) Power consumption.
- 11) Response timing.
- 12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
- 13) Special requirements or features, such as specifications for ambient operating conditions.
- 14) Features and options that are furnished.
- b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
  - 1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
  - 2) Include a list of tag numbers for which it applies with each brochure or bulletin.
  - 3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
  - 4) Cross out models, features, options, or accessories that are not being provided.
  - 5) Clearly mark and identify special options and features.
- c. Organization: Index the data sheets and brochures in the submittal by systems or loops.
8. Control panel hardware submittal:
  - a. Submit the following in 1 submittal package.
  - b. Complete and detailed bills of materials:
    - 1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
    - 2) Include all items within an enclosure.
  - c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
  - d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
  - e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
  - f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
    - 1) The manufacturer's model number or other identifying product designation.
    - 2) Tag and loop number.
    - 3) System to which it belongs.
    - 4) Site to which it applies.
    - 5) Input and output characteristics.
    - 6) Requirements for electric power.
    - 7) Device ambient operating requirements.
    - 8) Materials of construction.
9. Schedule of values:
  - a. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express





purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

10. Installation recommendations:
  - a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
11. Training submittals:
  - a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
  - b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
  - c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
  - d. Training course plan submittals:
    - 1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01756 - Commissioning.
    - 2) Describe any student pre-requisites for the course or training activity.
    - 3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
    - 4) Submit training materials.
  - e. Incorporate all submittal review comments into the course.
  - f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
12. Project Record documents:
  - a. Furnish as specified in Section 01770 - Closeout Procedures.
  - b. Record Drawing requirements:
    - 1) Provide Project Record Drawing of all Instrumentation Drawings.
    - 2) Update Record Drawings weekly.
    - 3) Record Drawings must be fully updated as a condition of the monthly progress payments.
    - 4) Clearly and neatly show all changes including the following:
      - a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
  - c. Shop drawings:
    - 1) General:
      - a) Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:





- (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
  - b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders, digital bus network equipment, and other equipment related to the PCS.
  - c) Generate all drawings developed for this project utilizing AutoCAD by Auto Desk Version 2012 or later:
    - (1) Furnish on CD-ROM disks containing the following for each drawing:
      - (a) Original CAD files in DWG format.
      - (b) PDF version.
    - (2) Provide hard copies on 11-inch by 17-inch plain bond paper.
  - d) Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
    - (1) Should an error be found in a shop drawing during installation or process start-up of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
    - (2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
    - (3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using plain bond paper.
    - (4) Provide electronic copies of these documents on CD-ROM disks in AutoCAD DWG 2010 format or later and PDF format. Size all drawings to be readable and legible on 11-inch by 17-inch media.
  - e) Submittal Documents:
    - (1) Provide an interim submittal of Record Documents after the PCS system Functional Testing.
    - (2) Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01782 - Operation and Maintenance Data or the General Requirements.
  - f) Review and Corrections:
    - (1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
    - (2) Promptly correct and re-submit Record Documents returned for correction.
- 2) Furnish written information prepared specifically for this Project using Microsoft Word and PDF formats and printed on 8.5-inch by 11-inch plain bond paper:
  - a) Provide electronic copies of these documents on CD-ROM disks.



- d. Review and corrections:
  - 1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
  - 2) Promptly correct and re-submit record documents returned for correction.
- 13. Loop Drawings:
  - a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
    - 1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
    - 2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
    - 3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
  - b. Show every instrument and I/O point on at least one loop diagram.
  - c. Provide a complete index in the front of each bound volume:
    - 1) Index the loop drawings by systems or process areas.
  - d. Provide drawings showing definitive diagrams for every instrumentation loop system:
    - 1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
    - 2) Furnish a separate drawing sheet for each system or loop diagram.
  - e. In addition to the ISA-5.4 requirements, show the following details:
    - 1) Functional name of each loop.
    - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
    - 3) Show all terminal numbers, regardless of the entity providing the equipment.
    - 4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
    - 5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
    - 6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
    - 7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
  - f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.
- 14. Instrument Installation Drawings:
  - a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
  - b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.



- c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
  - d. For each detail, provide, as a minimum, the following contents:
    - 1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
    - 2) Ambient temperature and humidity where the instrument is to be installed.
    - 3) Corrosive qualities of the environment where the instrument is to be installed.
    - 4) Hazardous rating of the environment where the instrument is to be installed.
    - 5) Process line pipe or tank size, service and material.
    - 6) Process tap elevation and location.
    - 7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
    - 8) Routing of tubing and identification of supports.
    - 9) Mounting brackets, stands, anchoring devices, and sun shades.
    - 10) Conduit entry size, number, location, and delineation between power and signal.
    - 11) NEMA ratings of enclosures and all components.
    - 12) Clearances required for instrument servicing.
    - 13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
15. Control Panel Drawings:
- a. Layout Drawings:
    - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
    - 2) As a minimum, include the following information:
      - a) To scale front, side, and plan views.
      - b) Dimensions.
      - c) Interior and exterior arrangements.
      - d) Mounting information, including conduit entrance location.
      - e) Finish data.
      - f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
      - g) Nameplate legend including text, letter size, materials, and colors.
  - b. Wiring and piping diagrams:
    - 1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
    - 2) Include the following information:
      - a) Name of panel.
      - b) Wiring and piping sizes and types.
      - c) Terminal strip numbers.
      - d) Wire tags and labels.
      - e) Functional name and manufacturer's designation for items to which wiring and piping are connected.



- f) Electrical control schematics in accordance with ANSI standards.
  - c. Installation drawings:
    - 1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
    - 2) Provide scaled drawings and show the position of the equipment at its intended installation location.
    - 3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
    - 4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
- 16. Schematic Diagrams:
  - a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
  - b. Include device and field connection terminal numbers on all schematic diagrams.
  - c. Incorporate equipment manufacturer's shop drawing information into the schematic diagrams in order to document the entire control system.
- 17. Control System Diagram:
  - a. Submit a complete set of control system diagrams including the following information:
    - 1) All PLCs, workstations, printers, communication devices, and communication links:
      - a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
    - 2) All cables required for communication requirements.
    - 3) Show each component fully annotated with conduit size and number associated with the power source.
- 18. Process Control Software Submittal:
  - a. In accordance with Product Data and Shop Drawing general requirements.
  - b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
    - 1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
  - c. A complete listing of the PCS system point I/O database:
    - 1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
    - 2) Organize on a site-by-site basis, separate by point type.
    - 3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
    - 4) Upon completion of the Work, update all I/O lists to indicate the final as-built configuration of the systems:
      - a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.



- d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
- e. Preliminary overview, screens, station graphic displays, and preliminary reports.
- 19. Instrumentation and Control System Contractor Statement of Qualifications:
  - a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
- 20. Control Descriptions:
  - a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
    - 1) Include all functions depicted or described in the Contract Documents.
    - 2) Include within the Control Description content:
      - a) All specific requirements.
      - b) All common requirements that pertain in general to all loops.
      - c) Listing all ranges, setpoints, timers, values, counter values, etc.
- 21. Test Procedure Submittals:
  - a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
    - 1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
    - 2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
- 22. Test reports:
  - a. As specified in Section 01330 - Submittal Procedures.

## **1.05 QUALITY ASSURANCE**

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. ICSC qualifications:
  - 1. General information on the proposing company:
    - a. Document that the ICSC Company has been actively involved in the instrumentation, PLC-based control systems business for a minimum of five years and has adequate facilities, organization structure, manpower, and technical and managerial expertise to properly perform the Work as specified in these Specifications.
  - 2. Document that the ICSC has a qualified permanent service facility:
    - a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and process start-up all of the instrumentation, control, telemetry, SCADA and control systems hardware and software furnished under this Contract, including remote diagnostic capability.
    - b. Document in-house resource of permanent personnel experienced in the design and programming of equipment and systems as specified in these Specifications.
    - c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.



- d. Document that the firm is a recognized or certified “system integrator partner” or similar designation for the control software and PLC system being supplied for this Project.
    3. Similar project experience of the company:
      - a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring and panel assembly drawings), software configuration and documentation, field testing, calibration and process start-up, operator instruction, and maintenance training. In addition, provide the following information for each project:
        - 1) Name of plant or system owner, contact name, and current telephone number. Design engineer’s name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for prequalification.
        - 2) Manufacturer and model number(s) of the PLC based control system and the computer-based SCADA system used for both hardware and software.
        - 3) Brief description of the system.
        - 4) Approximate number of input and output signals: analog, digital, and fieldbus.
        - 5) Brief application software description.
        - 6) Contracted cost of the system, separate by base amount and any change orders for the completed projects.
        - 7) Duration of the project and date of completion.
    4. Information on the proposed Project team members:
      - a. Provide the name and resume of the individual persons who will be responsible for each of the following:
        - 1) Office engineering and management of this Project.
        - 2) Lead for software configuration/programming.
        - 3) Individual who will be responsible for the hardware and hardware interface design.
        - 4) Individual who will be responsible for field testing, calibration, and process start-up.
        - 5) Individual who will be responsible for operator training.
      - b. All of these individuals must be permanent employees of the proposing firm.
    5. Determination of the proposed ICSC qualifications is at the sole discretion of the Engineer.
  - C. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
  - D. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.
  - E. ICSC:





1. Contractor, through the use of a qualified ICSC, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system including application software, for a complete, integrated and functional PCIS system.
3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 01600 - Product Requirements.
- B. Special instructions:
  1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
- C. Tagging:
  1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
  2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
  3. Tag instruments immediately upon receipt in the field.
  4. Prominently display identification on the outside of the package.
  5. Utilize the Tag and Loop Number identifications shown on the P&IDs.
- D. Delivery and inspection:
  1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. Site conditions:
  1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
  2. Seismic classification:
    - a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612 - Seismic Design Criteria.
  3. Wind:
    - a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614 - Wind Design Criteria.
  4. Altitude, temperature and humidity:
    - a. As specified in Section 01610 - Project Design Criteria.





- b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
- c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
  - 1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
- 5. Area classifications:
  - a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.

## 1.08 SEQUENCING

- A. General:
  - 1. As specified in Section 01312 - Project Meetings and Section 01756 - Commissioning.
  - 2. Testing requirements are specified in Section 01756 - Commissioning and Section 17950 - Commissioning for Instrumentation and Controls.
  - 3. General scheduling requirements are specified in Section 01321 - Schedules and Reports.
  - 4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
  - 5. Commissioning requirements as specified in Section 01756 - Commissioning.
- B. Pre-submittal conferences:
  - 1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
  - 2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
    - a. Vendor control panels.
    - b. Chemical feed systems.
    - c. Motor control centers.
    - d. Switchgear.
    - e. Variable frequency drives.
    - f. Lighting.
    - g. Engine generators.
- C. General Field Start-Up and testing procedures:
  - 1. As specified in Section 01756 - Commissioning.
- D. Installation testing:
  - 1. As specified in Section 01756 - Commissioning.
  - 2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.



3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.

E. Training:

1. As specified in Section 01756 - Commissioning.

F. Functional testing:

1. Representatives from each of the following groups shall be in attendance during the functional Testing: Programmer. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
2. Loop validation test.
3. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
  - a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
  - b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
  - c. Loop validation certifications:
    - 1) After the field device loop tests have been successfully completed as specified in Section 17950 - Commissioning for Instrumentation and Controls for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
      - a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

- G. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.

H. Process Operational Period:

1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

## **1.09 SCHEDULING (NOT USED)**

## **1.10 WARRANTY**

- A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in Documents 00700 - General Conditions and 00712 - Supplementary Conditions.



## **1.11 SYSTEM PROCESS START-UP**

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
  - 1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

## **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.13 MAINTENANCE**

- A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by the Contract Documents.
- C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.
- D. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.
- B. Allowable manufacturers are specified in individual instrument and equipment specifications.

### **2.02 SYSTEM DESCRIPTION**

- A. General requirements:
  - 1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
    - a. Preparing hardware submittals for field instrumentation.
    - b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
    - c. Prepare the test plan, the training plan, and the spare parts submittals.
    - d. Procure all hardware.
    - e. Fabricate panels.
    - f. Perform factory tests on panels.
    - g. Perform bench calibration and verify calibration after installation.



- h. Oversee and certify installation of the PCS system.
  - i. Oversee, document, and certify loop testing.
  - j. Oversee, document, and certify system.
  - k. Installation Testing.
  - l. Oversee and document Functional Testing.
  - m. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
  - n. Prepare operation and maintenance manuals.
  - o. Conduct training classes.
  - p. Integrate the PCS with instrumentation and control devices provided under other sections.
  - q. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
    - 1) As specified in the Contract Documents.
    - 2) For Owner furnished items.
    - 3) For interfaces with existing equipment.
  - r. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
  - s. Perform all required corrective and preventative maintenance.
- 2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
  - 3. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
  - 4. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.
  - 5. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
  - 6. Defective Work:
    - a. As specified in Document 00700 - General Conditions.

### **2.03 EXISTING PRODUCTS (NOT USED)**

### **2.04 MATERIALS**

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.



- B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

## **2.05 MANUFACTURED UNITS (NOT USED)**

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS**

- A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.
- B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.
- C. Signal transmission:
1. Analog signals:
    - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
    - b. Furnish electrical analog signals outside control panels that are 4-to-20 milliamperes 24 VDC, except as indicated.
    - c. Electrically or optically isolate all analog signals from other signals.
    - d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
    - e. Maintain the total 4-to-20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
    - f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
  2. Discrete input signals:
    - a. As indicated in the controller hardware specification.
  3. Discrete output signals:
    - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
    - b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
    - c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
    - d. Provide interposing relays as required for functionality of the control circuit.
  4. Signal performance and design criteria:
    - a. Stability:
      - 1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
    - b. Response:
      - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.



- c. Agreement:
  - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
- d. Repeatability:
  - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
- e. Sensitivity:
  - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
- f. Performance:
  - 1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:

- 1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
- 2. Alarm contacts: Fail to the alarm condition.
- 3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:

- 1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
- 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
- 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
- 4. Terminate the signal cable shield on a dedicated grounding terminal block.
- 5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

## 2.08 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.
- B. Nameplates:
  - 1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
  - 2. All nameplates shall be of identical style, color, and material throughout the facility.
  - 3. Device nameplates shall include:
    - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
      - 1) Device tag and loop number ID (e.g., FIT-60.011).
      - 2) PLC ID (e.g., PLC-11).
      - 3) Power information (e.g., PCM-11, 120 VAC).



- b. White lettering on a black background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL**

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.
- B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
  1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.
- C. Source Test is specified in Section 17950 - Commissioning for Instrumentation and Controls.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION**

- A. The ICSC is encouraged to attend a pre-bid conference and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.
- B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
- C. Provide a complete instrumentation and control system:
  1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
  1. Verify all dimensions as indicated on the Drawings:
    - a. Actual field conditions govern all final installed locations, distances, and levels.





2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
  3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.
- C. The PCIS configurations are diagrammatic:
1. The locations of equipment are approximate unless dimensioned.
  2. Where Project conditions require, make reasonable changes in locations and arrangements.
- D. Field instruments installation:
1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
  2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
    - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
    - b. Provide sun shields for all field electronic instruments located outdoors.
  3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
    - a. Type of flexible conduit required for the area classification:
      - 1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
    - b. Maximum length of 18 inches.
  4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
    - a. Special cable applications shall be in accordance with the NEC.
  5. Verify the correctness of each installation:
    - a. Polarity of electric power and signal connections.
  6. Ensure all process connections are free of leaks.
  7. Provide a power disconnect switch for each 120 VAC powered instrument which does not have a built-in power disconnect:
    - a. Disconnect enclosure suitable for the area classification:
      - 1) As specified in Section 16050 - Common Work Results for Electrical.
- E. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
  2. All control panels, LCS/VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- F. Instrument tagging:
1. As specified in Section 16075 - Identification for Electrical Systems.
  2. Provide all field-mounted instruments with nameplates:



- a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
      - 1) Affix tags with stainless steel wire fasteners.
  3. Provide all back of panel instruments with nameplates:
    - a. Engraved with the instrument's full tag number as indicated on the Drawings:
  4. Provide all front of panel instruments with a nameplate:
    - a. Engraving to include the following:
      - 1) Instrument's full tag number.
      - 2) Service description.
    - b. Nameplates:
      - 1) Secure nameplates to the panel with stainless steel screws.
      - 2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.
- G. Cable and conductor termination:
  1. Terminate all cables and conductors on terminal blocks.
  2. Terminal block enclosures:
    - a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.
- H. Surge protection:
  1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
  2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/2-ampere fuse between power supplies and receiver surge protectors.
  3. Provide voltage surge protection for 4 wire transmitters and analyzers:
    - a. Protect both power source and signal loop.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Owner Training:
  1. Demonstration requirements are specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.08 FIELD QUALITY CONTROL**

- A. Inspection:
  1. Allow for inspection of PCIS installation as specified in Section 01450 - Quality Control.
  2. Provide any assistance necessary to support inspection activities.
  3. Engineer inspections may include, but are not limited to, the following:
    - a. Inspect equipment and materials for physical damage.
    - b. Inspect installation for compliance with Drawings and Specifications.



- c. Inspect installation for obstructions and adequate clearances around equipment.
- d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
- e. Inspect equipment nameplate data to verify compliance with design requirements.
- f. Inspect cable terminations.
- g. Inspect/witness instrument calibrations/verifications.
- 4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Instrument Installation Inspection:

- 1. Provide any assistance necessary to support inspection activities.
- 2. Inspections may include, but are not limited to, the following:
  - a. Inspect equipment and materials for physical damage.
  - b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
  - c. Inspect installation for compliance with Drawings and Specifications.
  - d. Inspect installation for obstructions and adequate clearances around equipment.
  - e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
  - f. Inspect equipment nameplate data to verify compliance with design requirements.
  - g. Inspect cable terminations.
  - h. Inspect/witness instrument calibrations/verifications.
- 3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.
- 4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Commissioning for Instrumentation and Controls. Additional general requirements are specified in Section 01756 - Commissioning.

C. Installation supervision:

- 1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
  - a. Installation resources:
    - 1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
  - b. Provide technical assistance to installation personnel by telephone:
    - 1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
  - c. Periodic inspections during the construction period.
  - d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
  - e. Field verify accuracy and calibration of all instruments.



3.09

## **ADJUSTING**

- A. Control valves:
  - 1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
  - 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.
- B. Make all revisions necessary to the control system software, as directed by the Engineer.
  - 1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

## **3.10 CLEANING**

- A. As specified in Section 01770 - Closeout Procedures.
- B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.
- C. Clean all panel surfaces.
- D. Return to new condition any scratches and/or defects.
- E. Wipe all instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
  - 1. Neatly coil and label all spare wiring lengths.
  - 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.
- G. As specified in other sections of the Contract Documents.

## **3.11 PROTECTION**

- A. Protect all Work from damage or degradation until date of Substantial Completion.

## **3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 17100

### CONTROL STRATEGIES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Contractor-developed loop description submittal requirements.
  - 2. General programming requirements.
  - 3. Common control functions:
    - a. General control and monitoring functions to be provided throughout the PCS system.
      - 1) These requirements apply to all systems, and supplement the specific loop descriptions in Section 17101 - Specific Control Strategies and information indicated on the Drawings.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
- C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.
- D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.
- E. Slew rate: Rate of change in respect to time.
- F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.
- G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



**1.06 QUALITY ASSURANCE (NOT USED)**

**1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)**

**1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

**1.09 SEQUENCING (NOT USED)**

**1.10 SCHEDULING (NOT USED)**

**1.11 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

**1.12 SYSTEM START-UP (NOT USED)**

**1.13 OWNER'S INSTRUCTIONS (NOT USED)**

**1.14 COMMISSIONING (NOT USED)**

**1.15 MAINTENANCE (NOT USED)**

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS (NOT USED)**

**2.02 EXISTING PRODUCTS (NOT USED)**

**2.03 MATERIALS (NOT USED)**

**2.04 MANUFACTURED UNITS (NOT USED)**

**2.05 EQUIPMENT (NOT USED)**

**2.06 COMPONENTS (NOT USED)**

**2.07 ACCESSORIES (NOT USED)**

**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL (NOT USED)**

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**



### 3.03 INSTALLATION (NOT USED)

### 3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. General programming requirements:
  - 1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
    - a. Submit names for Owner approval.
    - b. Unless otherwise noted, utilize floating-point format for all PLC algorithms and calculations.
    - c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
  - 2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
  - 3. Reusable PLC code blocks:
    - a. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
    - b. New code blocks that the Contractor would like to use as a standard shall be submitted to Owner for review and approval.
  - 4. Documentation:
    - a. All control logic shall be completely annotated including all rungs, instructions, and tags.
    - b. Each routine shall have a title and a detailed description of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description.
    - c. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
    - d. Digital tag descriptions shall include the On and Off state labels.
    - e. Complete, grammatically correct sentences and terminology, consistent with water treatment processes, shall be utilized in the development of rung and routine descriptions.
    - f. All equations developed in the process logic shall be fully documented in the rung or routine description. A description of each constant and variable utilized in the equation shall be defined including engineering units.
  - 5. Program slew rates for setpoints to limit the effect of updated setpoints on the process:
    - a. Provide for control setpoints and manual speed and position selections.
    - b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
    - c. Provide operator access to change slew rates from the HMI.
  - 6. Saved setpoints:
    - a. Provide an operator selection to save all setpoint values.
    - b. Where possible use a DFB or AOI to provide an operator selection to restore all setpoints to the initial start-up value.





- c. Provide an operator selection to restore all setpoints to the last saved value.
7. Store a copy of all adjustable parameters and accumulated and integrated totals in PCS:
  - a. Upon re-loading of the PLC program, re-load these values to the PLC from PCS or processor memory card.
  - b. PLCs provide a minimum 2 week data storage to provide for data accumulation and later communication to the Historian in the event of a network interruption.
8. Calculated values:
  - a. Program calculations such that division by zero errors cannot occur.
  - b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
  - c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
  - d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years. Utilize manufacturer AOI/DFBs etc. where possible.
9. Timers:
  - a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
    - 1) The settling timers may be overridden by setting the timer to 0 seconds.
10. Control Panel status:
  - a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
    - 1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
  - b. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including but not limited to the following:
    - 1) PLC cabinet over-temperatures from high temperature switch.
    - 2) Intrusion status on all enclosures equipped with intrusion switches.
    - 3) AC power failure:
      - a) Monitor ahead of UPS.
    - 4) DC power supply failure:
      - a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
    - 5) UPS failure signal.
    - 6) UPS Low Battery signal.
    - 7) Digital bus network Coupler and or Gateway failure signal.
    - 8) Ethernet Switch failure signal.
11. PLC system communication status:
  - a. Furnish a minimum of 1 screen to display all communication errors and status within the PCS:
    - 1) Communication between PCS and PLCs, PLC to PLC, PLC to RIO and PLC and or PCS to VCP.
    - 2) 4-20 mA HART interface cards.



- 3) Digital bus network status:
    - a) Profibus scanners.
  - 4) Modbus Gateway modules.
  - 5) Display status of each node, and summary of failures over the past 60 minutes.
  - b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
  - c. In the event of communications loss:
    - 1) Continue normal operation at each PLC.
    - 2) Where control parameters are received over a communications link:
      - a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
        - (1) Ensure that the operator can control the process using PC\IS HAND mode at the local LOI.
      - b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
        - (1) Provide a manual over-ride entry at the local LOI to allow an operator to enter a different value for any such remote signal.
        - (2) Generate an alarm whenever an over-ride value is in use.
12. 4-20 mA Hart interface cards:
- a. Provide the following HART protocol information for each populated channel on the card:
    - 1) Process variable values:
      - a) Primary process variable (analog): 4-20 mA current signal.
      - b) Primary process variable (digital): Digital value in engineering units.
      - c) Percent range: Primary process variable expressed as percent of calibrated range.
      - d) Loop current: Loop current value in milliamps.
      - e) Secondary process Variable 1: Digital value in engineering units available from multivariable devices (if applicable).
    - 2) Host commands:
      - a) Set primary variable units.
      - b) Set upper range.
      - c) Set lower range.
      - d) Set damping value.
      - e) Set message.
      - f) Set tag.
      - g) Set date.
      - h) Set descriptor.
      - i) Perform loop test: Force loop current to specific value.
      - j) Initiate self-test: Start device self-test.
      - k) Get more status available information.
    - 3) Status and diagnostic alerts:
      - a) Device malfunction: Indicated device self-diagnostic has detected a problem in device operation.



- b) Configuration changed: Indicates device configuration has been changed.
- c) Cold start: Indicates device has gone through power cycle.
- d) More status available: Indicates additional devices status data available.
- e) Primary variable analog output fixed: Indicates device in fixed current mode.
- f) Primary variable analog output saturated: Indicates 4-20 mA signal is saturated.
- g) Secondary variable out of limits: Indicates secondary variable value outside the sensor limits.
- h) Primary variable out of limits: Indicates primary variable value outside the sensor limits.
- 4) Device identification:
  - a) Instrument tag: User defined, up to 8 characters.
  - b) Descriptor: User defined, up to 16 characters.
  - c) Manufacturer name (code): Code established by HCF and set by manufacturer.
  - d) Device type and revision: Set by manufacturer.
  - e) Device serial number: Set by manufacturer.
  - f) Sensor serial number: Set by manufacturer.
- 5) Calibration information:
  - a) Date: Date of last calibration, set by user.
  - b) Upper range value: Primary variable value in engineering units for 20 mA point, set by user.
  - c) Lower range value: Primary variable value in engineering units for 4 mA point, set by user.
  - d) Upper sensor limit: Set by manufacturer.
  - e) Lower sensor limit: Set by manufacturer.
  - f) Sensor minimum span: Set by manufacturer.
  - g) PV damping: Primary process variable damping factor, set by user.
  - h) Message: Scratch pad message area (32 characters), set by user.
  - i) Loop current transfer function: Relationship between primary variable digital value and 4-20 mA current signal.
  - j) Loop current alarm action: Loop current action on device failure (upscale/downscale).
  - k) Write protect status: Device write-protect indicator.
- C. Common control functions:
  - 1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
  - 2. Alarms:
    - a. Generate alarms within the PLC logic.
    - b. Indicate alarms at the LOI and HMI. Enable acknowledgement from either the HMI or the LOI.
    - c. Generate high, high-high, low, and low-low level alarms where indicated:
      - 1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.



- 2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
    - d. Flash all alarm and fail conditions and their respective indicators on the PCS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
    - e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
      - 1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
    - f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
    - g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
      - 1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
      - 2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
    - h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
    - i. Furnish an alarm silence pushbutton at each PCM, LOI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
    - j. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
      - 1) The lamp test may sequence through blocks of lights.
      - 2) Minimum on time for each lamp during lamp test 15 seconds.
    - k. Horns and Beacons:
      - 1) Activate PCM horn and beacon on all critical alarms and on other alarms as defined by the Facility Alarm Philosophy.
      - 2) Deactivate PCM horn and beacon when PCM reset pushbutton is activated.
      - 3) Silence PCM horn when PCM silence pushbutton is activated.
    - l. Dual analog instruments:
      - 1) For applications where 2 or more analog instruments are measuring the same process variable:
        - a) Generate an operator adjustable percent deviation alarm.
        - b) Allow operator to take each instrument out of service when an instrument is out of service.
3. Where a reset is shown for counts, totals and times maintained in the PLC:
  - a. Provide a reset selection on the HMI screen that displays the value.
  - b. Provide a preset function on the HMI to allow an operator-entered value to become the current accumulated total.
  - c. Limit access to the reset and preset functions to operators with suitable security level.
  - d. Log the value before reset, operator, time, and date of reset in the PCS archive.
  - e. Log the value before preset, preset value, operator, time, and date of preset in the PCS archive.



4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
  - a. Display total starts on PCS screens, and provide a reset function.
  - b. Where indicated, calculate number of starts for each day:
    - 1) Display current day and previous day starts on PCS displays.
    - 2) Do not reset daily start count when overall count is reset.
    - 3) Archive starts for each day through PCS.
5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
  - a. Display total run time in hours on PCS screens.
  - b. Where indicated, calculate total run time for each day:
    - 1) Display current day and previous day run time on the HMI to the nearest 0.1 hour.
    - 2) Do not reset daily run time when overall time is reset.
    - 3) Archive run time for each day through PCS.
6. For all monitored analog values:
  - a. Convert all values to engineering units in floating-point format within the PLC.
  - b. Flows and Weights:
    - 1) Totalize flows in the PLC logic:
    - 2) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
    - 3) Where no totalizer input is shown, integrate the analog input over time.
    - 4) Display totals on the HMI and LOI.
    - 5) Archive totals to the historical database through PCS.
  - c. Generate an alarm whenever an over-ride value is in use.
  - d. Calculate hourly, daily, and monthly averages:
    - 1) Calculations shall be performed by the PLC.
    - 2) Display averages on the HMI, and archive through PCS.
  - e. Calculate minimum and maximum values each day, and month:
    - 1) Calculations may be performed by the PLC or PCS.
    - 2) Display minima and maxima on the HMI, and archive through PCS.
  - f. Generate an alarm whenever an over-ride value is in use.
7. Analog data processing:
  - a. Engineering units conversion:
    - 1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
  - b. Analog magnitude checking:
    - 1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.
8. Tank and vessel levels:
  - a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
    - 1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
  - b. Monitor rate of change of volume on all tanks and vessels:
    - 1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output).



- Generate an alarm whenever the volume decreases faster than this rate.
- 2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.
9. I/O filtering and processing:
- a. Analog input filtering:
    - 1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
    - 2) Monitor analog input signal quality:
      - a) Over range: The input value is above the normal range (typically over 21 mA).
      - b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
      - c) Generate alarms for over or under range inputs.
      - d) Do not use over or under range values for control or calculation purposes:
        - (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
    - 3) Digital input filtering (proving timer):
      - a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
      - b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
10. Instrument scaling (HMI/LOI):
- a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
    - 1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
11. PCS HAND-OFF-AUTO:
- a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCS, accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
    - 1) PCS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
    - 2) PCS HAND: Enables PCS Manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
    - 3) PCS OFF: Automated PCS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.





- 4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.
12. Interlocks:
  - a. Implement software interlocks where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS HAND:
13. Permissives:
  - a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
  - b. Apply software permissives when equipment is operating in PCS AUTO or PCS HAND.
14. Process control algorithms:
  - a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
    - 1) When the error between process variable and setpoint is beyond a setpoint deadband:
      - a) Jog valve or ramp speed in the required direction for a preset "Jog Time" or until the process variable reaches or passes the setpoint.
      - b) Then hold speed or position through a setpoint "Hold Time."
      - c) Continue alternating jog and hold until the error is less than the deadband.
    - 2) Provide operator access to Jog Time and Hold Time setpoints from the HMI.
  - b. PID algorithms: Use where indicated, or where necessary to provide fast response:
    - 1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
      - a) Display Output, CV.
      - b) Display Setpoint, SP.
      - c) Display Process Variable, PV.
      - d) Allow for operator selection of Automatic or Manual control of the output.
      - e) Under Manual control of output allow the operator to enter the desired output value.
      - f) Allow for input of the 3 Proportional, Integral, and Derivative tuning parameters.
      - g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCS), or when the equipment has reached a physical limit.
      - h) When controlled equipment is being operated in remote PCS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.





- i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
- 15. Equipment alternating and sequencing:
  - a. Distribute number of starts and run time equally between identical equipment.
- 16. Motor control:
  - a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
    - 1) Display current REMOTE status on the PCS screens.
  - b. Monitor the device's running status from the starter auxiliary or run status input:
    - 1) Display the current status (running or stopped) on the PCS screens.
    - 2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
    - 3) Provide time stamp for each start.
    - 4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
  - c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCS AUTO or PCS HAND control modes based upon operator selection using the PCS screens.
  - d. Starting, stopping and running when the device LOR is in LOCAL:
    - 1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
    - 2) With the LOR switch in the OFF position, the motor is prohibited from running.
    - 3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
  - e. Starting, stopping and running when the device LOR is in REMOTE:
    - 1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
      - a) Provide "Control Activation" timers for each piece of controlled equipment:
        - (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
          - (a) De-activate the output.
          - (b) Place the device in a "Failed" state.
          - (c) Generate a "Failed to Respond" alarm.
    - 2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
      - a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
        - (1) Keep the RUN output off or the STOP output on.
        - (2) Place the device in a "Failed" state.



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- operating speed should be approximately the same as flow of one pump at Start Next speed).
- (3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.
  - (4) Operate all equipment at the same speed following the output of the speed control algorithm.
- d) When two or more pieces of equipment are running, monitor for a "Stop Next" condition:
- (1) Where flow rate is monitored, use a preset "Stop Next" flow rate for each possible number and combination of equipment:
    - (a) Determine initial "Stop Next" speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the "Start Next" speed.
  - (2) When the "Stop Next" condition exists through a preset time delay:
    - (a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset "Start Next" speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
    - (b) Operate all remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.
17. Gate and valve control:
- a. Monitor the device's LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
    - 1) Display current REMOTE status on PCS screens.
  - b. Start an "Open Activation" timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS HAND):
    - 1) Initially set "Open Activation" time to twice the normal opening time.
    - 2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the "Open Activation" time period:
      - a) De-activate the open output.
      - b) Place the device in a "Failed" state.
      - c) Generate a "Failed to Open" alarm.
  - c. Start a "Close Activation" timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCS AUTO, or CLOSE was selected in PCS HAND):
    - 1) Initially set "Close Activation" time to twice the normal closing time.
    - 2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the "Close Activation" time period:
      - a) De-activate the close output.



- b) Place the device in a "Failed" state.
  - c) Generate a "Failed to Close" alarm.
- d. Limit the number of open/close /commands so that it does not exceed the manufacturer requirements.
- e. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a "Position Error" timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
  - 1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
  - 2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
  - 3) Initially set the "Position Error" time to 60 seconds.
  - 4) If the LSR position does not change, and position error stays outside of the setpoint error through the "Position Error" time period:
    - a) Place the device in a "Failed" state.
    - b) Generate a "Position Fail" alarm.
- f. Provide separate time delay settings for each function and for each device.
- g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a "Failed" state and generate an "Invalid State" alarm.
- h. Re-establish PLC control of a device in a "Failed" state only after one of the following:
  - 1) An operator turns the device's LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
- i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
- j. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) per hour in the PLC:
  - 1) Display count on the HMI.

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 FIELD QUALITY CONTROL (NOT USED)**

### **3.08 ADJUSTING (NOT USED)**

### **3.09 CLEANING (NOT USED)**



### **3.10 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.11 PROTECTION (NOT USED)**

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 17101

### SPECIFIC CONTROL STRATEGIES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Loop descriptions:
    - a. Specific control requirements and functional descriptions for individual control loops.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
    - a. Include all functions depicted or described in the Contract Documents.
    - b. Include the following within each loop description:
      - 1) All requirements specific to that loop.
      - 2) Common control requirements applicable to that loop.
      - 3) List of all ranges, setpoints, timers, values, counters, etc.
  - 2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.
  - 3. Loop description format: As specified in this Section.
- B. Loop number and title.
  - 1. References:
    - a. List P&IDs that are specifically referenced.
  - 2. Abstract:
    - a. General description of how the loop works, what devices are involved, and how the process will be controlled.
    - b. Process values, setpoints, and limits, including units and ranges:
      - 1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.





3. Hardwired control:
  - a. Detailed description of the control functions at the local level.
  - b. Function of local operator interfaces.
  - c. Operation of hardwired field pilot controls:
    - 1) Pushbuttons.
    - 2) Selector switches.
    - 3) Potentiometers.
    - 4) Pilot lights, indicators, and other displays.
4. Hardwired interlocks:
  - a. Explanation of the operation of system interlocks and hardwired permissive conditions.
5. PLC control:
  - a. Detailed description of the control functions that are under control of the PLC.
  - b. Operator controls and automatic controls.
  - c. Setpoints, alarms, etc.:
    - 1) Include units and ranges for analog values.
    - 2) Include span and range for analog inputs and outputs.
    - 3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
  - d. Control sequences.
  - e. Software interlocks:
    - 1) Operation of system software interlocks.
6. PCS/LOI/HMI control:
  - a. Detailed description of the operator controls.
  - b. Setpoints, alarms, etc.
7. Indicators and alarms:
  - a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
8. Failure modes:
  - a. List any failure modes specific to the loop that are not covered in the common control strategies.

#### **1.06 QUALITY ASSURANCE (NOT USED)**

#### **1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)**

#### **1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

#### **1.09 SEQUENCING (NOT USED)**

#### **1.10 SCHEDULING (NOT USED)**

#### **1.11 WARRANTY (NOT USED)**

#### **1.12 SYSTEM START-UP (NOT USED)**

#### **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.14 COMMISSIONING (NOT USED)**

#### **1.15 MAINTENANCE (NOT USED)**



## **PART 2 PRODUCTS (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION (NOT USED)**

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION**

- A. Loops PMP-111, PMP-121 and PMP-131, PMP-141 - Digester No. 5 and No. 6 Sludge Mixing Pumping System
  - 1. References:
    - a. Drawing 10N01 – Digester No. 5
    - b. Drawing 10N02 – Digester No. 6
  - 2. Abstract:
    - a. Digester mixing pumps circulate and mix sludge in the digester.
    - b. Each digester mixing system includes two duty pumps. The digester mixing system can operate with one duty pump when the second pump is out of service.
    - c. The mixing pumps withdraw sludge from the center of the digester through a common suction header. The mixing pumps discharge sludge through mixing nozzles connected to a common discharge header.
    - d. PMP-111 and –121 mix sludge in Digester No. 5
    - e. PMP-131 and –141 mix sludge in Digester No. 6
  - 3. Local control:
    - a. The sludge circulation pump is provided with a local control station (LCS) with the following controls:
      - 1) Local-Off-Remote (L-O-R) selector switch
      - 2) Start push button
      - 3) Stop push button
    - b. With the LOR in LOCAL, the sludge circulation pump is controlled locally by the start and stop push buttons.
    - c. With the LOR switch in REMOTE, the sludge circulation pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
    - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the sludge circulation pump starts.
    - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the sludge circulation pump is controlled via the PLC/SCADA.
  - 4. Hardwired control:
    - a. Hardwired interlocks/Overload Programmed Interlocks:
      - 1) The sludge circulation pump is stopped and prohibited from starting if one of the following occurs:
        - a) Pump motor winding high temperature.
        - b) Pump motor overload.
      - 2) Once the condition has cleared, the pump will restart.
  - 5. PLC control:
    - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.



- b. When the sludge circulation pump is in READY status, the pump can be controlled through the PLC.
  - 6. PCS/LOI/HMI control:
    - a. When the sludge circulation pump is in READY status, the pump can be controlled by the start-stop buttons on the digester sludge circulation graphic display screen.
  - 7. SCADA indicators and alarms:
    - a. Refer to PIDs.
- B. Loop FLA-151 and FLA-152 – Digester Gas Flares
  - 1. References:
    - a. Drawing 10N03
  - 2. Abstract:
    - a. Digester gas flares are used for burning excess digester gas. Excess gas that is not utilized in the combined heat and power (CHP facility) is flared using two waste gas burners.
    - b. The waste gas burners include propane-fueled pilot ignition systems.
    - c. The waste gas burners operate with one unit in service during normal conditions. The units are set at different pressures such that the second burner is brought online when the target gas pressure is reached.
  - 3. Control:
    - a. The flare system is controlled locally via the vendor control panel
    - b. Refer to PIDs for PLC I/O and HMI indication.
- C. FOG SYSTEM:
  - 1. References:
    - a. Drawings 20N01 through 21N04
    - b. Mechanical Drawings 20M01 through 20M04
  - 2. General Description:
    - a. The FOG (Fats, Oils, and Grease) Receiving system includes an offloading system with a valve, rock trap/macerator, and pump; a FOG tank with a tank mixing/heating system and level monitoring system; a digester feed pump; and control valves used to automate the FOG SYSTEM.
    - b. Local controls for each equipment and control valve are described in their respective control strategies. This section includes the control strategy for remote automatic mode for all of the FOG equipment and control valves.
    - c. To operate in remote automatic mode, all equipment and control valves within the FOG System must be set to remote automatic mode.
  - 3. General Description of AUTO Operation:
    - a. FOG Offloading sequence:
      - 1) FOG Offloading Control Panel with card reader and light indicators, which is designed for the FOG hauler's use, is provided near the offloading equipment adjacent to the FOG fill connection for FOG offloading operation. Prior to offloading, the level in the FOG Tank is checked to ensure there is available storage volume in the FOG Tank to accommodate the hauler's tanker volume, which is read from the hauler's ID card.
      - 2) The Truck Offloading Pump is used to pump the FOG truck contents through the Rock Trap / Macerator and into the FOG Tank. The Rock Trap / Macerator removes large debris and grinds other material to help prevent downstream clogs.



- 3) High-High Level from FOG tank level instrument LIT-211 shall close FOG off-loading control valve FCV-211 and initiate the FOG macerator shutdown protocols.
- 4) A red light (in use) at the FOG Offloading Control Panel will indicate that the FOG Tank is unavailable for FOG delivery. A green light (ready) will indicate to incoming FOG Haulers that the FOG Tank is available for delivery. A flashing yellow light (fill) at the FOG Offloading Control Panel will indicate to the FOG Hauler that they cannot disconnect their fill hose.
- b. FOG Mixing/Heating sequence:
  - 1) A mixing/heating sequence is automatically initiated when the FOG tank WSE level reaches and operator adjustable target low level setpoint. When the FOG tank WSE level drops below the operator adjustable target low level setpoint, the mixing/heating sequence is automatically stopped.
- c. FOG Digester Feed sequence:
  - 1) Operator will select the target flow rate and the target feed time per digester prior to starting the Digester Feed sequence. The Digester Feed sequence will pump the FOG Tank contents to the digesters until an operator low level setpoint level in the FOG tank is reached.
4. Local Controls and Instrumentation:
  - a. See each specific equipment and control valve control strategy.
5. AUTO Controls and Instrumentation:
  - a. FOG SYSTEM operation is controlled by the PLC and the Offloading, Mixing/Heating, and Digester Feed sequences can be initiated at the FOG Offloading Control Panel or at the SCADA/HMI
  - b. FOG Offloading Sequence:
    - 1) To initiate the FOG Offloading Sequence, the FOG Hauler scans a valid access card.
    - 2) Prior to offloading, the FOG Tank level transmitter (LIT-211) is used to check if there is available storage volume in the FOG Tank to accommodate the hauler's tanker volume, which is linked to the hauler's ID card:
      - a) If there is enough volume in the FOG tank to accommodate the hauler's tanker volume:
        - (1) The FOG hauler connects their truck hose to the FOG Receiving Facility fill connection and presses the "START OFFLOADING SEQUENCE" button at the FOG Offloading Control Panel.
          - (a) The "START OFFLOADING SEQUENCE" may also be initiated by operations personnel via SCADA.
        - (2) The green light (ready) at the FOG Offloading Control Panel shall turn off and the red light (in use) at the FOG Offloading Control Panel shall turn on.
        - (3) The FOG tank level measurement device shall measure the liquid level in the FOG Tank and the level reading shall be recorded to the PLC as the "PRE-DELIVERY LEVEL" for that date and time.
        - (4) The FOG Offloading Control Valve shall open.
        - (5) A yellow light (fill) at the FOG Offloading Control Panel shall begin flashing to indicate to the FOG Hauler that the hose



- should not be disconnected. The red light shall remain lit while the yellow light is flashing.
- (6) The FOG Rock Trap / Macerator shall start.
  - (7) After finishing offloading FOG, the FOG offloading pump shall press the "STOP OFFLOADING SEQUENCE" button at the FOG Offloading Control Panel.
  - (8) The FOG Offloading Control Valve shall close.
  - (9) The flashing yellow light (fill) at the FOG Offloading Control Panel shall turn off to indicate to the FOG Hauler that their fill hose can be disconnected. The red light (in use) shall remain lit.
  - (10) The FOG tank level measurement device shall measure the liquid level in the FOG Tank and the level reading shall be recorded to the PLC as the "POST-DELIVERY LEVEL" for that date and time.
  - (11) The PLC shall calculate the "FOG VOLUME DELIVERED" using the difference between "PRE-DELIVERY LEVEL" and "POST-DELIVERY LEVEL." The calculated "FOG VOLUME DELIVERED" shall be recorded to the PLC for that date, time, and FOG Hauler card ID.
- b) If there is not enough volume in the FOG tank to accommodate the hauler's tanker volume:
- (1) The green light (ready) at the FOG Offloading Control Panel shall turn off and the red light (in use) at the FOG Offloading Control Panel shall begin flashing to indicate the driver shall call Operations staff.
  - (2) The FOG Offloading Control Valve shall remain closed.
- 3) Mixing/Heating Sequence:
- a) The FOG Mixing Pump shall start when the tank level reaches an operator adjustable low level setpoint.
  - b) The FOG Hot Water Pump shall start after the FOG Mixing Pump has been operating for an operator adjustable period of time.
  - c) The 3-way temperature control valve blends hot water supply with hot water return water from the heat exchanger to control the temperature of the FOG entering the heat exchanger at an operator adjustable setpoint. The temperature of the FOG at the inlet of the heat exchanger is measured by temperature transmitter TIT-212.
  - d) If the temperature of the hot water supply to the heat exchanger reaches an operator adjustable setpoint, the position of the 3-way temperature control valve shall be moved to full bypass to exclude the addition of hot water from the main hot water loop. When the temperature decreases to a value below the HIGH setpoint, automatic control resumes.
  - e) The FOG Mixing Pump and FOG Hot Water Pump shall operate until the FOG temperature at the inlet of the FOG heat exchanger reaches an operator-adjustable setpoint.
  - f) While the level in the FOG Tank remains above an operator adjustable low level setpoint, the FOG Mixing Pump and FOG Hot Water Pump shall intermittently operate based on an operator adjustable setpoint in minutes per hour.

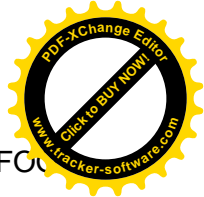






- 2) Start push button
      - 3) Stop push button
      - 4) Speed pot
    - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
    - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
    - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
    - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
  4. PMP-211 Hardwired control:
    - a. Hardwired interlocks/Overload Programmed Interlocks:
      - 1) The sludge circulation pump is stopped and prohibited from starting if one of the following occurs:
        - a) Pump motor winding high temperature.
        - b) Pump motor overload.
        - c) Pump high discharge pressure (via SCADA)
      - 2) Once the condition has cleared, the pump will restart.
  5. PMP-211 PLC control:
    - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
    - b. When the pump is in READY status, the pump can be controlled through the PLC.
  6. PMP-211 PCS/LOI/HMI control:
    - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
  7. PMP-211 SCADA indicators and alarms:
    - a. Refer to PIDs.
  8. FCV-211 Local control:
    - a. The FOG offloading control valve is provided with the following controls
      - 1) Local-Off-Remote (L-O-R) selector switch
      - 2) Open-Stop-Close (OSC) selector switch
    - b. With the LOR in LOCAL, the offloading control valve is controlled locally by the OSC selector switch.
    - c. With the LOR switch in REMOTE offloading control valve is controlled via the PLC/SCADA.
  9. FCV-211 SCADA indicators and alarms:
    - a. Refer to PIDs.
- E. Loop PMP-212– FOG TANK FEED, CIRCULATION, AND HEATING SYSTEM:
1. References:
    - a. Drawing 20N02
  2. Abstract
    - a. One fats, oils, and grease (FOG) Tank is equipped with a tank level monitoring system and a FOG tank mixing system. The FOG Mix Pump (PMP-212) is used in the operation of the FOG Receiving Facility as described in the FOG SYSTEM control strategy.
    - b. A FOG Tank Mix Pump (PMP-212) is provided to mix the FOG inside the tank. The pump shall start and stop based on operator-adjustable FOG level setpoints.





- c. A heat exchanger (HEX-211) is provided between the Mix Pump and FOG Tank.
- d. Temperature transmitter TIT-212 is provided upstream of the heat exchanger to measure the FOG temperature.
- e. The FOG level in the FOG Tank is measured by a level transmitter (LIT-211). An alarm shall activate when the FOG level reaches an operator-adjustable "High Level" setpoint. This alarm is used to inform plant staff the FOG level in the FOG tank is near the emergency overflow pipe.
- 3. Local control:
  - a. The pump is provided with a local control station (LCS) with the following controls:
    - 1) Local-Off-Remote (L-O-R) selector switch
    - 2) Start push button
    - 3) Stop push button
  - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
  - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
  - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
  - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
- 4. Hardwired control:
  - a. Hardwired interlocks/Overload Programmed Interlocks:
    - 1) The pump is stopped and prohibited from starting if one of the following occurs:
      - a) Pump motor winding high temperature.
      - b) Pump motor overload.
    - 2) Once the condition has cleared, the pump will restart.
- 5. PLC control:
  - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
  - b. When the pump is in READY status, the pump can be controlled through the PLC.
- 6. PCS/LOI/HMI control:
  - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
- 7. SCADA indicators and alarms:
  - a. Refer to PIDs.

F. Loop PMP-213– DIGESTER FOG FEED VALVE AND PUMP

- 1. References:
  - a. 20N03
- 2. Abstract:
  - a. The Digester FOG Feed Pump (PMP-213) and two automated Digester FOG Feed Valves (FCV-212 and FCV-213) are used to empty the FOG Tank and deliver FOG to Digester Nos. 5 and 6.
  - b. The Digester FOG Feed Pump shall start and stop based on operator-adjustable FOG level setpoints inside the tank. The Digester FOG Feed Pump is equipped with a variable frequency drive (VFD) to allow the pump to operate at an operator-adjustable flow rate.



- c. A flowmeter (FIT-211) is provided on the discharge of the Digester FOG Feed Pump to measure the FOG flow.
  - d. The Digester FOG Feed Valves operate as shown in the FOG SYSTEM description.
- 3. Local control:
  - a. The pump is provided with a local control station (LCS) with the following controls:
    - 1) Local-Off-Remote (L-O-R) selector switch
    - 2) Start push button
    - 3) Stop push button
    - 4) Speed pot
  - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
  - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
  - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
  - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
- 4. Hardwired control:
  - a. Hardwired interlocks/Overload Programmed Interlocks:
    - 1) The sludge circulation pump is stopped and prohibited from starting if one of the following occurs:
      - a) Pump motor winding high temperature.
      - b) Pump motor overload.
      - c) Pump high discharge pressure (via SCADA).
    - 2) Once the condition has cleared, the pump will restart.
- 5. PLC control:
  - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
  - b. When the pump is in READY status, the pump can be controlled through the PLC.
- 6. PCS/LOI/HMI control:
  - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
- 7. SCADA indicators and alarms:
  - a. Refer to PIDs.
- 8. FCV-212, FCV-213 Local control:
  - a. The Digester FOG feed control valve is provided with the following controls
    - 1) Local-Off-Remote (L-O-R) selector switch
    - 2) Open-Stop-Close (OSC) selector switch
  - b. With the LOR in LOCAL, the valve is controlled locally by the OSC selector switch.
  - c. With the LOR switch in REMOTE valve is controlled via the PLC/SCADA.
- 9. FCV-212, FCV-213 SCADA indicators and alarms:
  - a. Refer to PIDs.



- G. Loop PMP-214, PMP-215 – FOG RECIRCULATION HOT WATER SYSTEM:
1. Reference: Drawing 20N04
  2. Abstract:
    - a. FOG Recirculation Line Hot Water Pump (PMP-214 and -215) are used for pumping the hot water to the heat exchanger to heat the FOG. The FOG recirculation hot water system pulls water from the primary hot water loop.
    - b. The hot water system includes two pumps, one duty and one standby.
    - c. One three-way valve (FCV-214) shall be designated to provide the heating load requirement by diluting the right amount of hot fluid with the colder HWR (hot water return) from the FOG heat exchanger (HEX-211).
    - d. Heat exchanger HEX-211 is provided downstream of the FOG Hot Water Pumps.
    - e. Temperature transmitter TIT-213 is provided upstream of the heat exchanger to measure the HWS temperature.
    - f. Temperature transmitter TIT-214 is provided downstream of the heat exchanger to measure the HWR temperature.
  3. Local control:
    - a. The pump is provided with a local control station (LCS) with the following controls:
      - 1) Local-Off-Remote (L-O-R) selector switch
      - 2) Start push button
      - 3) Stop push button
    - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
    - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
    - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
    - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
  4. Hardwired control:
    - a. Hardwired interlocks/Overload Programmed Interlocks:
      - 1) The pump is stopped and prohibited from starting if one of the following occurs:
        - a) Pump motor winding high temperature.
        - b) Pump motor overload.
      - 2) Once the condition has cleared, the pump will restart.
  5. PLC control:
    - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
    - b. When the pump is in READY status, the pump can be controlled through the PLC.
  6. PCS/LOI/HMI control:
    - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
  7. SCADA indicators and alarms:
    - a. Refer to PIDs.



#### **ART 4 REPAIR/RESTORATION (NOT USED)**

##### **4.01 RE-INSTALLATION (NOT USED)**

##### **4.02 FIELD QUALITY CONTROL (NOT USED)**

##### **4.03 ADJUSTING (NOT USED)**

##### **4.04 CLEANING (NOT USED)**

##### **4.05 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### **4.06 PROTECTION (NOT USED)**

##### **4.07 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 17208

### LEVEL MEASUREMENT: RADAR PULSE TIME OF FLIGHT (PTOF)

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Non-contact radar (PTOF) level instruments.
- B. Provide all instruments identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. PTOF: Pulse Time of Flight.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Emerson, Rosemount 5400.
  - 2. Endress+Hauser, Micropilot M.
  - 3. Siemens/Milltronics, LR250.
  - 4. Ohmart Vega, VegaPuls.
  - 5. Ametek Drexelbrook, DR7000 Series.

### **2.02 MANUFACTURED UNITS**

- A. Pulse Time of Flight:
  - 1. General:
    - a. Instrument emits radar pulses via a transmitter, with a frequency range of 6.3 GHz to 26 GHz.
    - b. The pulses reflect from the surface being measured and are received back at the instrument via a sensor.
    - c. The instrument measures the pulse travel time between the transmitter, surface, and receiver to calculate the level.
    - d. Safety:
      - 1) Shall not generate frequency waves with power levels hazardous to humans.
  - 2. Performance requirements:
    - a. Accuracy: Level:
      - 1) 0.25-inch.
  - 3. Element:
    - a. Level element must conform to the process material compatibility as indicated on the Instrument Data Sheets or the Instrument Index.



- b. Connections:
  - 1) Process: The antenna design shall be suitable for mounting in a nozzle as indicated on the Instrument Data Sheets or the Instrument Index.
  - 2) The design shall be such that product condensation on the antenna shall not affect the performance of the gauge. It shall be possible to choose between either parabolic-, cone-, rod-shaped antennas.
- 4. Transmitter:
  - a. Microprocessor-based signal converter/transmitter.
  - b. Power supply:
    - 1) 24 VDC - 2-wire loop powered.
    - 2) Power consumption: 15 VA maximum.
  - c. Outputs:
    - 1) Isolated 4-20 mA DC with HART communication protocol.
  - d. Backlit digital display for level or volume.
  - e. Self-diagnostics and automatic data checking.
  - f. Signal integrity:
    - 1) Immune to radio frequency and electromagnetic interference with field strength of 15 volts/meter or less over a frequency range of 50 Hz to 460 MHz.
    - 2) Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
  - g. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
    - 1) Indication: Local - 5-digit display.
  - h. Enclosure rating: NEMA Type 4X.
  - i. Electrical connection: 1/2-inch male NPT.

### **2.03 ACCESSORIES**

- A. Software: Provide Windows based PC software for configuration and echo mapping.
- B. Provide sun shield for outdoor installations.
- C. Provide a remote loop indicator/display in accordance with Section 17710, and as show on the drawings. Loop indicator/display shall be able to accept a 4-20 mA signal and provide an isolated 4-20 mA signal to the PLC.

### **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each level transmitter at a facility that is traceable to NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.





## **ART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
  - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.
- C. Furnish 2 hours of Owner training.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



### 3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be indicated on the Drawings, specified in the Specifications or both.
  2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system.

END OF SECTION





## SECTION 17302

### FLOW MEASUREMENT: MAGNETIC FLOWMETERS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Full-body magnetic flowmeters.
- B. Provide all instruments identified in the Contract Drawings.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. International Organization for Standardization (ISO):
  - 1. 9000 - Quality management systems -- Fundamentals and vocabulary.
  - 2. 17025 - General requirements for the competence of testing and calibration laboratories.
- C. National Institute of Standards and Technology (NIST).
- D. NSF International (NSF).

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Include sizing information from the manufacturer that includes:
  - 1. Chart of the measurement error from zero to maximum measured volumetric flow range indicated in data sheets.
  - 2. Indication of all input parameters and their values used in the calculations.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.



2. Physical conditions:
  - a. Installation and mounting requirements.
  - b. Location within the process.
  - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  1. Endress+Hauser: Promag 53.
  2. Rosemount – 8700.
  3. Krohne - IFC.
  4. Toshiba - LF

## **2.02 MANUFACTURED UNITS**

- A. Magnetic flowmeter:
  1. General:
    - a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
    - b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
    - c. Include for each magnetic flow metering system:
      - 1) A metering tube with electrodes (sensor).
      - 2) Signal cable.
      - 3) Transmitter integral or remote as indicated on the Drawings.



- 4) Flowmeter grounding rings.
2. Performance requirements:
  - a. Accuracy:
    - 1) 0.25 percent of flow rate from 10 to 100 percent of full-scale for velocities ranging between 1.9 to 10 feet per second.
  - b. Repeatability:
    - 1) 0.25 percent of rate.
3. Element:
  - a. Metering tube:
    - 1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
    - 2) Liner material in conformance with:
      - a) Manufacturer's recommendations for the intended service.
      - b) NSF certified for all drinking water applications.
    - 3) Electrodes type and material in conformance with:
      - a) Manufacturer's recommendations for the intended service.
      - b) Utilize a minimum of 2, self-cleaning electrodes.
    - 4) Meter terminal housing NEMA Type 4X, unless installed in locations such as vaults that will experience submergence. In those applications NEMA 6P is required.
      - a) Unless specifically noted otherwise in the instrument data sheets.
    - 5) Meter coating consisting of epoxy painted finish.
    - 6) Components:
      - a) 2 grounding rings:
        - (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
        - (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.
4. Transmitter:
  - a. Power supply:
    - 1) As indicated in the data sheets.
    - 2) Power consumption: 60 VA maximum.
  - b. Outputs:
    - 1) As noted in the instrument data sheets.
    - 2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
  - c. Microprocessor-based signal converter/transmitter.
  - d. Utilize DC pulse technique to drive flux-producing coils.
  - e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
  - f. Operator keypad interface.
  - g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
  - h. Integral low flow cut-off zero return.
  - i. Programmable parameters including:
    - 1) Meter size.
    - 2) Full-scale flow rate.
    - 3) Magnetic field frequency.
    - 4) Time constant.
  - j. Data retention for a minimum of 5 years without auxiliary main or battery power.



- k. Self-diagnostics and automatic data checking.
- l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
- m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

## **2.03 ACCESSORIES**

- A. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.
- B. Provide sunshades for all transmitters located outdoors.
- C. Provide galvanic isolation gaskets, nylon/Teflon™ flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each flow metering system at a facility that is traceable to the NIST. ISO-17025 accredited test facility with certified accuracy traceable to NIST.
- C. Evidence of accreditation shall originate from a national verification agency such as A2LA.
- D. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
  - 1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
  - 2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
  - 3. Manufacturer shall archive all calibration reports for future reference.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. For instruments located outdoors or where instrument elements and transmitters are separated by conduit located outside the building envelope, provide surge protection devices at the transmitters.





### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection.

### **3.05 ADJUSTING**

- A. Field Verification:
  - 1. Verify factory calibration of all instruments in accordance with the manufacturer's instructions.
  - 2. The transmitter and sensor to include a method to verify flow meter performance to the original manufacturer specifications.
  - 3. Verification should be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.
  - 4. The verification report should be compliant to common quality systems such as ISO 9000 to prove reliability of the meter specified accuracy.
  - 5. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES**

- A. Instrument Data Sheets included in this Section.
- B. The provided information does not necessarily include all required instruments.
- C. Provide all instruments identified in the Contract Documents:
  - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.
  - 2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION





## SECTION 17401

### PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Diaphragm seals.
  - 2. Annular seals.
- B. Provide all seals identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Manufacturer's installation instructions.
    - b. Seal type.
    - c. Body materials.
    - d. Diaphragm material.
    - e. Fill fluid type.
    - f. Seal size.
    - g. Options.
    - h. Process connection.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.



- c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide spare annular seal for every size indicated in the project.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Diaphragm seals:
  - 1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
    - a. Ashcroft:
      - 1) Flushing connection: Type 741.
      - 2) Without flushing connection: Type 740.
    - b. Mansfield and Green:
      - 1) Flushing connection: Type SGT.
      - 2) Without flushing connection: Type SBT.
    - c. Wika, Type L990.40.
    - d. Emerson, Rosemount.
  - 2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
    - a. Ashcroft:
      - 1) Flushing connection: Type 201.
      - 2) Without flushing connection: Type 200.
      - 3) Saddle mount: Type 205.



- b. Mansfield and Green:
  - 1) Flushing connection: Type SG.
  - 2) Without flushing connection: Type SB.
- c. Wika:
  - 1) Type L990.10.

- B. Annular seals:
  - 1. One of the following or equal:
    - a. Ashcroft, Wafer Isolation Ring.
    - b. Onyx Valve.

## 2.02 MANUFACTURED UNITS

- A. Diaphragm seals:
  - 1. General:
    - a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
  - 2. Requirements:
    - a. Seal type:
      - 1) Metallic diaphragm: Welded to upper housing.
      - 2) Elastomer diaphragm: Bonded to upper housing.
    - b. Process connection: 1 inch NPT.
    - c. Instrument connection: 1/2 inch NPT.
    - d. Material Construction: Type 316 Stainless Steel.
    - e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
    - f. Flush port plug: Same material of construction as diaphragm lower housing.
    - g. Provide fill/bleed connection.
    - h. Mounting: As indicated in the Contract Documents.
    - i. Provide Type 316 stainless steel armored capillary for all remote installations.
    - j. Nuts and bolts: Type 316 stainless steel.
    - k. Materials of construction:
      - 1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
        - a) Diaphragm: Type 316 stainless steel.
        - b) Lower housing: Type 316 stainless steel.
        - c) Upper housing: Manufacturer's standard.
        - d) Fill fluid: Silicone oil.
      - 2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
        - a) Diaphragm: Type 316 stainless steel.
        - b) Lower housing: Type 316 stainless steel.
        - c) Upper housing: Manufacturer's standard.
        - d) Fill fluid: Silicone oil.
- B. Annular seals:
  - 1. General:
    - a. Inside diameter of annular seal shall provide uninterrupted flow:
      - 1) There shall be no dead ends or crevices.



- 2) Process flow shall be sufficient to make the annular seal self-cleaning.
  - b. The pressure sensing flexible cylinder shall measure pressure around the full inside circumference of the pipeline.
2. Requirements:
  - a. Pressure rating: Equivalent to the ANSI flanges.
  - b. Materials of construction:
    - 1) Inner flexible cylinder: Manufacturer's standard.
    - 2) Body:
      - a) Carbon Steel with epoxy coating.
    - 3) Assembly flanges: To match adjacent piping.
    - 4) Fill fluid: Silicone oil.
  - c. Instrument connection: 1/2 inch NPT.

### **2.03 ACCESSORIES (NOT USED)**

### **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Do not use Teflon thread seal tape on pressure instruments with silicone oil fill fluid.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING (NOT USED)**

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17402

### PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Valve manifolds and instrument valves.
- B. Provide all valves identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Valve type.
    - b. Body material.
    - c. Size.
    - d. Options.
  - 2. Shop drawings:
    - a. Mounting details for all manifold valves.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.



- C. Notify the Engineer if any installation condition does not meet the valve manufacturer's recommendations or specifications.
- D. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

#### **1.07 PROJECT OR SITE CONDITIONS**

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. Provide valves suitable for the installed site conditions including, but not limited to, material compatibility, process, and ambient temperatures.

#### **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Valve manifold:
  - 1. One of the following or equal:
    - a. Anderson Greenwood.
    - b. Hex Valve.
    - c. Noshok.
    - d. Emerson, Rosemount.
- B. Block and bleed valve:
  - 1. One of the following or equal:
    - a. Anderson Greenwood.
    - b. Hex Valve.



- C. Gauge valve:
  - 1. One of the following or equal:
    - a. Anderson Greenwood.
    - b. Hex Valve.
- D. Level sensor isolation valve:
  - 1. One of the following or equal:
    - a. Indu-Tech, Level Sensor Isolation Valve.
    - b. DeZURIK, Level Sensor Isolation Valve.
    - c. Tyco, Rovalve Isolation Knife Gate Valve.

## 2.02 MANUFACTURED UNITS

- A. Valve manifolds:
  - 1. General:
    - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
    - b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
  - 2. Requirements:
    - a. Bonnet lock pin to prevent accidental loosening.
    - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
    - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
    - e. Manifold valves shall allow for direct or remote instrument mounting.
    - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
    - g. Materials of construction:
      - 1) Body material: Type 316 stainless steel.
      - 2) O-Ring: Teflon.
    - h. 2-Valve manifolds:
      - 1) 1 isolation valve and 1 drain/vent and calibration valve.
    - i. 3-Valve manifolds:
      - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
      - 2) Plugged vent connections used for vent/drain or calibration.
    - j. Blowdown 5-valve manifold:
      - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
    - k. Metering 5-valve manifold:
      - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
- B. Block and bleed valves:
  - 1. General:
    - a. Valve shall provide process isolation and venting/draining capabilities.
    - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
    - d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.



2. Requirements:
  - a. Materials of construction:
    - 1) Body material: Type 316 stainless steel.
    - 2) O-Ring: Teflon.
- C. Gauge valves:
  1. General:
    - a. Valve shall provide process isolation from pressure instrument.
    - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
  2. Requirements:
    - a. Materials of construction:
      - 1) Body material: Type 316 stainless steel.
      - 2) O-Ring: Teflon.
- D. Level sensor isolation valves:
  1. General:
    - a. Valve shall provide process isolation from level diaphragm.
    - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
  2. Requirements:
    - a. Materials of construction:
      - 1) Body material: Type 316 stainless steel.
      - 2) Flange diameter size: 3 inches.

## **2.03 ACCESSORIES**

- A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
- B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION**

- A. Examine the installation location and verify it will work properly when installed.
  1. Notify the Engineer promptly if any installation condition does not meet the manufacturer's recommendations or specifications.

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all valves to the Engineer before commissioning.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17403

### PRESSURE/VACUUM MEASUREMENT: SWITCHES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Pressure/vacuum switches.
- B. Provide all instruments specified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Electronic type pressure switch: One of the following or equal:
  - 1. Ashcroft, B Series Type 400.
  - 2. United Electric, 400 Series.

## **2.02 MANUFACTURED UNITS**

- A. Mechanical type pressure switches:
  - 1. General:
    - a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
  - 2. Performance requirements:
    - a. Accuracy:
      - 1) Within 1.0 percent of range.
    - b. Repeatability:
      - 1) Within 1.0 percent of range.
  - 3. Element:
    - a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
    - b. Overpressure:
      - 1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      - 2) Minimum 400 percent of nominal range without leakage or rupture.
    - c. Sensing element shall not require ambient temperature compensation.
    - d. Wetted materials: Stainless steel



- e. Setpoint:
    - 1) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
  - f. Adjustable deadband.
  - g. Switch elements:
    - 1) Snap acting.
    - 2) Rated at 5 A, 125/250 VAC.
  - h. Enclosure: Epoxy coated:
    - 1) NEMA Type 4.
    - 2) NEMA Type 4X.
    - 3) NEMA Type 7.
  - i. Switch mounting:
    - 1) Process connection: 1/2-inch NPT.
  - 4. Components:
    - a. Provide all necessary hardware for pressure switch mounting.
- B. Electronic indicating type pressure switches:
- 1. General:
    - a. Pressure switch shall utilize ceramic or polysilicon thin film pressure transducer.
  - 2. Performance requirements:
    - a. Pressure range:
      - 1) As specified in data sheets.
    - b. Accuracy:
      - 1) Within 1.0 percent of range.
    - c. Repeatability:
      - 1) Within 1.0 percent of range.
  - 3. Element:
    - a. Type: Ceramic or polysilicon thin film.
    - b. Overpressure:
      - 1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      - 2) Minimum 400 percent of nominal range without leakage or rupture.
    - c. Sensing element shall not require ambient temperature compensation.
    - d. Wetted materials: Stainless steel.
  - 4. Transmitter:
    - a. Setpoint:
      - 1) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
    - b. Adjustable deadband.
    - c. Switch elements:
      - 1) Snap acting.
    - d. Enclosure: Epoxy-coated.
      - 1) NEMA Type 4X.
    - e. Local display:
      - 1) 4-digit LCD or LED.
      - 2) Scaled in engineering units.
    - f. Switch mounting:
      - 1) Process connection: 1/2-inch NPT.



- g. Power supply:
  - 1) 120 VAC.
  - 2) Power consumption: 3 VA maximum.
- h. Outputs:
  - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
- i. Relay outputs:
  - 1) Form C contacts: 2.
- j. Rated 5 amps at 120 VAC.
- k. Components:
  - 1) Provide all necessary hardware for pressure switch mounting.
  - 2) Provide sun shield for outdoor installations.

## **2.03 ACCESSORIES**

- A. Pulsation dampeners and snubbers:
  - 1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
  - 2. Materials: Stainless steel.
  - 3. Mount pulsation dampener or snubber integrally to the pressure switch.
  - 4. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in data sheets or as indicated on the Drawings and as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
  - 1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.
- C. Furnish block and bleed valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.
- D. Furnish gauge valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.
- E. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
  - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.



## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
  - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES**

- A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
  - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.
  - 2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION





## SECTION 17404

### PRESSURE/VACUUM MEASUREMENT: GAUGES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Pressure/vacuum gauges.
- B. Provide all instruments specified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. American Society of Mechanical Engineers (ASME):
  - 1. B40.100 - Pressure Gauges and Gauge Attachments.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.





- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Ashcroft:
  - 2. Wika.
  - 3. Ametek U.S. Gauge.

## **2.02 MANUFACTURED UNITS**

- A. General:
  - 1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.
- B. Performance requirements:
  - 1. Pressure range:
    - a. As specified in the Contract Documents.
  - 2. Accuracy:
    - a. Grade 2A, as defined by ASME B40.100.
    - b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
    - c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
  - 3. Element:
    - a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
    - b. Socket tips for bellows and Bourdon® tube:
      - 1) Materials: Type 316 stainless steel.



- c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
- d. Wetted materials: Type 316 stainless steel.
- 4. Dial gauge:
  - a. Dial size: 4-1/2 inches.
  - b. Dial case material:
    - 1) Maximum pressure less than 10 pounds per square inch:
      - a) Phenolic.
    - 2) Maximum pressure greater than or equal to 10 pounds per square inch:
      - a) 316 Stainless steel.
  - c. Provide safety gauge with safety blow out through the back or top of the unit.
  - d. Dial face: Gasketed shatterproof glass or polycarbonate.
  - e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
  - f. Provide gauge locks where possible.
  - g. Hermetically sealed.
  - h. Connection and mounting:
    - 1) Direct mounted and suitable for outdoor installation.
    - 2) 1/2-inch NPT.
    - 3) Connection material: 316 Stainless steel.
  - i. Pointer: Externally adjustable.

## **2.03 ACCESSORIES**

- A. Pulsation dampeners and snubbers:
  - 1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
  - 2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
  - 3. Materials: Type 316 stainless steel.
  - 4. Mount pulsation dampener or snubber integrally to the pressure gauge.
  - 5. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
  - 1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- C. Provide means for gauge isolation as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves:
  - 1. Mount valve manifold integrally to the gauge.
  - 2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



- B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

#### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.05 ADJUSTING**

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
  - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

#### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



### 3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be indicated on the Drawings, specified in the Specifications or both.
  2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION





## SECTION 17602

### TEMPERATURE MEASUREMENT: TEMPERATURE GAUGE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Temperature gauges.
- B. Provide all instruments identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Bimetallic type temperature gauge:
  - 1. Manufactures: One of the following or equal:
    - a. Ashcroft, Type EI.
    - b. Weiss Instruments, Series BM.
    - c. Noshok, 300 Series.

## **2.02 MANUFACTURED UNITS**

- A. Bimetallic type temperature gauges:
  - 1. General:
    - a. Temperature gauges shall consist of a bimetallic temperature sensor with a dial-type temperature gauge.
  - 2. Performance requirements:
    - a. Temperature range:
      - 1) As indicated in the Contract Documents.
    - b. Accuracy:
      - 1) Within 1.0 percent of range.
  - 3. Element:
    - a. Type: Bimetallic.
    - b. Stem material: 316 Stainless steel.
    - c. Temperature gauge sensor shall be tamperproof, hermetically sealed, and silicon dampened.
    - d. Process connection: 1/2-inch NPT.





4. Dial gauge:
  - a. Dial size: 3 inches.
  - b. Dial case material: 316 Stainless steel.
  - c. Dial face: Gasketed shatterproof glass.
  - d. Orientation: Straight or angled as required to provide most convenient direct viewing.
  - e. Mounting: Direct mounted and suitable for outdoor installation.
  - f. External adjustable recalibration screw.

## **2.03 ACCESSORIES**

- A. Thermowell:
  1. Unless otherwise noted, provide Thermowell with each temperature gauge.
  2. Process connection: As indicated in the contract documents.
  3. Thermowell material: Material compatible with the service fluid identified and recommended by the manufacturer for the process condition.
  4. Stem style: Straight or tapered.
  5. Immersion depth:
    - a. Minimum 3 inches or 10 times the diameter of the sensor protection tube or Thermowell, whichever is larger.
- B. Provide sunshades for outdoor installations.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
  1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION**

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
  1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



#### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.05 ADJUSTING**

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

#### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.09 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 17604

### TEMPERATURE MEASUREMENT: RTD

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. RTD temperature instruments.
- B. Provide all instruments identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. RTD - Resistance temperature detector.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.



- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Process Measurement:
    - a. Emerson, Rosemount 3144P transmitter with Series 214C sensor.
    - b. Siemens, SITRANS T.
    - c. Foxboro, Model RTT20.

## **2.02 MANUFACTURED UNITS**

- A. Process measurement:
  - 1. General:
    - a. Temperature measuring instrument shall include an RTD temperature element, transmitter, and thermowell.
  - 2. Performance requirements:
    - a. Accuracy:
      - 1) Within 0.25 percent of calibrated span.
    - b. Repeatability:
      - 1) 0.25 percent of full scale.
    - c. Sensor lead wire compensation: Maximum zero shift of 0.2 percent of the temperature range.
  - 3. Element:
    - a. 100-Ohm platinum thin film resistance temperature detector (RTD).
    - b. 3-wire.



- c. Hermetically-sealed, and enclosed in Type 316 stainless steel outer sheath.
- d. Single element temperature sensor shall be spring-loaded.
- 4. Transmitter:
  - a. Microprocessor based.
  - b. Compatible with 3-wire and 4-wire RTD inputs:
  - c. Local display:
    - 1) 5-digit LCD.
    - 2) Scaled in engineering units.
  - d. Power supply:
    - 1) 24 VDC - loop powered.
  - e. Outputs:
    - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
  - f. Transmitter enclosure:
    - 1) NEMA Type 7.
  - g. Transmitter mounting:
    - 1) As specified on the Instrument Data Sheets or Instrument Index.
    - 2) Connection to thermowell: 1/2-inch NPT.
    - 3) Provide all necessary hardware for transmitter mounting.

## **2.03 ACCESSORIES**

- A. Thermowell:
  - 1. Unless otherwise noted, provide a thermowell with each RTD.
  - 2. Process connection: As identified on instrument data sheet.
  - 3. Thermowell material: Type 316L stainless steel
  - 4. Stem style: As identified on instrument data sheet.
  - 5. Immersion depth:
    - a. Minimum 3 inches or 10 times the diameter of the thermowell, whichever is larger.
    - b. Where pipe diameter is inadequate for appropriate immersion depth, install thermowell in an elbow on the axis of the pipe.
    - c. As identified on instrument data sheet.
- B. Provide sunshades for outdoor installations.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
  - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.



## **ART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
  - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Apply thermally conductive silicone grease to the sensor tip before insertion in thermowell.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



### 3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.
  2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION







## SECTION 17710

### CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
    - a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
    - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
    - c. Control components.
    - d. Control panel installation.
- B. Provide all control panels identified in Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
  - 2. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
  - 3. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
- C. International Electrotechnical Commission (IEC):
  - 1. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
  - 2. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
- D. Underwriters Laboratories Inc. (UL):
  - 1. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.



2. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
3. 508 - Standard for Industrial Control Equipment.
4. 508A - Standard for Industrial Control Panel.
5. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
6. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
7. 1283 - Standard for Electromagnetic Interference Filters.
8. 1449 - Standard for Surge Protective Devices.

### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  1. The term "panel" in this Section is interchangeable with the term "enclosure."

### 1.04 SUBMITTALS

- A. Provide submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
  1. Product data:
    - a. Enclosure construction details and NEMA type.
    - b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
  2. Shop drawings:
    - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
      - 1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
    - b. Complete nameplate engraving schedule.
    - c. Structural details of fabricated panels.
  3. Calculations:
    - a. Provide installation details based on calculated shear and tension forces:
      - 1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
    - b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
      - 1) Weight including panel internal components.
      - 2) Seismic forces and overturning moments.
      - 3) Shear and tension forces in connections.
    - c. Cooling calculations, including but not limited to:
      - 1) Highest expected ambient temperature for the enclosure's location.
      - 2) Internal heat load.
      - 3) Exposure to direct sunlight.
      - 4) Dimensions of the enclosure in inches.



- 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:

1. Seismic panel construction:
  - a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612 - Seismic Design Criteria:
    - 1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
  - b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612 - Seismic Design Criteria. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

## 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
  1. Provide all components and equipment with UL 508 listing.
  2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
  3. Provide fuses for all equipment that is not UL or UR listed.
  4. Install all intrinsically safe circuits and equipment in accordance with UL698A.

## 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

## 1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

## 1.08 SEQUENCING (NOT USED)

## 1.09 SCHEDULING (NOT USED)



## **WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **1.11 SYSTEM START-UP (NOT USED)**

### **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

### **1.13 COMMISSIONING (NOT USED)**

### **1.14 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. As listed below in the individual component paragraphs.
- B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

### **2.02 SYSTEM DESCRIPTION**

- A. Panel dimensions:
  - 1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
    - a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
    - b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
    - c. Maximum panel depth: 30 inches, unless otherwise indicated.
- B. Structural design:
  - 1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

### **2.03 EXISTING PRODUCTS (NOT USED)**

### **2.04 MATERIALS**

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
  - 1. Enclosures shall have the following properties:
    - a. NEMA Type 1: Steel.
    - b. NEMA Type 4: Steel with gasketed door, raintight.



- c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
- d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
- e. NEMA Type 12: Steel with gasketed door, dusttight.
- f. NEMA Type 7: Cast aluminum.

B. Bolting material:

- 1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
- 2. Carriage bolts for attaching end plates.
- 3. All other bolted joints shall have S.A.E. standard lock washers.

## 2.05 MANUFACTURED UNITS

A. Panels/enclosures:

- 1. Manufacturers: One of the following or equal:
  - a. Rittal.
  - b. nVent/Hoffman.
  - c. Saginaw Control & Engineering.
- 2. Panel assembly:
  - a. General guidelines for panel fabrication include:
    - 1) Continuous welds ground smooth.
    - 2) Exposed surfaces free of burrs and sharp edges.
    - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
  - b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
- c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.



- e. Door construction:
  - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
  - 2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
  - 3) Heavy-gauge stainless steel hinges.
  - 4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
  - 5) Gasket installed to seal against roll lip on the enclosure opening.
- f. Latches:
  - 1) For panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
    - a) Provide padlock for each enclosure with padlock provisions.
  - 2) Include an oiltight key-locking, 3-point latching mechanism on each door:
    - a) Provide 2 keys per panel.
    - b) All locks keyed alike.
  - 3) For large NEMA Type 4 and NEMA Type 4X cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
- g. Panel cut-outs:
  - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
  - 2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
  - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
    - a) Large panel cutouts; for example, openings for local operator interfaces.
    - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
- 3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
  - a. Minimum 14-gauge, Type 304 stainless steel.
  - b. Captive stainless steel cover screws threaded into sealed wells.
  - c. Inside finish: White polyester powder coating.
  - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
- 4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
  - a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
  - b. Door hardware: 316 Stainless steel.
  - c. Provide factory installed rain canopy and sun shield for all enclosures with operator interface panels.
  - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.



- B. Arrangement of components:
1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
  2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
  3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
  4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
- C. Overcurrent protection:
1. Main overcurrent device:
    - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
      - 1) Door-mounted disconnect handles are not acceptable.
      - 2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
      - 3) Provide means to defeat the interlock.
      - 4) Lockable in the off position.
    - b. Control panels supplied with 120 VAC:
      - 1) Provide an internal breaker with the line side terminals covered by a barrier.
      - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
  2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
  3. Selection and ratings of protective devices:
    - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
    - b. Voltage rating: Not less than the voltage of the application.
    - c. Select current rating and trip characteristics to be suitable for:
      - 1) Maximum normal operating current.
      - 2) Inrush characteristics.
      - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
    - d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
      - 1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
      - 2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
      - 3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.





4. Provide a separate protective device for each powered electrical device:
  - a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
  - b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
    - 1) Size external fuse to open before any I/O-card-mounted fuses.
  - c. Individual discrete inputs shall use a 1/2-ampere fuse.
    - 1) Control loops shall use a 5-ampere fuse.
  - d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for 4-to- 20 milliamperes signals:
  - a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
    - 1) Label shall not cover or interfere with equipment manufacturer's instructions.
  - b. An individual 1/2-ampere fuse for each 4-to-20 milliamperes analog loop powered from the control panel.
  - c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
  - d. Manufacturers: One of the following or equal:
    - 1) Ferraz Shawmut.
    - 2) Littelfuse.
    - 3) Bussmann.
6. Fuse holders:
  - a. Modular type:
    - 1) DIN rail mounting on 35-millimeter rail.
    - 2) Touch-safe design: All connection terminals to be protected against accidental touch.
    - 3) Incorporates blown-fuse indicator.
    - 4) Plug-in style fuse terminals and fuse plugs are not acceptable.
  - b. Provide nameplate identifying each fuse:
    - 1) As specified in Section 16075 - Identification for Electrical Systems.
  - c. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, UT4-HESI Series.
    - 2) Allen-Bradley, 1492-FB Series B.
7. Control circuit breakers:
  - a. DIN rail mounting on 35-millimeter rail.
  - b. Manual OPEN-CLOSE toggle switch.
  - c. Rated for 250 VAC.
  - d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
  - e. Current ratings: As required for the application.
  - f. Provide nameplate identifying each circuit breaker:
    - 1) As specified in Section 16075 - Identification for Electrical Systems.
  - g. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, TMC Series.
    - 2) ABB.
    - 3) Allen-Bradley.
    - 4) Square D.
8. Electronic circuit protectors:
  - a. Used where a NEC Class 2 power circuit is required to protect devices with NEC Class 2 power supplies.



- b. DIN rail mounting on 35-millimeter rail.
- c. Rated for 24 VDC.
- d. 4 channels to feed 4 independent power feeds to separate devices.
- e. Output current ratings: As required for the application.
- f. LED input status indication.
- g. LED failure status of each channel indication.
- h. Fail contacts.
- i. Provide nameplate identifying each circuit electronic circuit protector module:
  - 1) As specified in Section 16075 - Identification for Electrical Systems.
- j. Manufacturers: One of the following or equal:
  - 1) Rockwell Automation 1692-TD014.
  - 2) Puls PISA11 series.

D. Conductors and cables:

- 1. Power and control wiring:
  - a. Materials: Stranded, soft annealed copper.
  - b. Insulation: 600 volts type MTW.
  - c. Minimum sizes:
    - 1) Primary power distribution: 12 AWG.
    - 2) Secondary power distribution: 14 AWG.
    - 3) Control: 16 AWG.
  - d. Color:
    - 1) AC power (line and load): Black.
    - 2) AC power (neutral): White.
    - 3) AC control: Red.
    - 4) AC control: Orange for foreign voltages.
    - 5) DC power and control (ungrounded): Blue.
    - 6) DC power and control (grounded): White with Blue stripe.
    - 7) Ground: Green.
- 2. Signal cables:
  - a. Materials: Stranded, soft annealed copper.
  - b. Insulation: 600 volts, PVC outer jacket.
  - c. Minimum size: 18 AWG paired triad.
  - d. Overall aluminum shield (tape).
  - e. Copper drain wire.
  - f. Color:
    - 1) 2-Conductor:
      - a) Positive (+): Black.
      - b) Negative (-): White and red.
    - 2) 3-Conductor:
      - a) Positive (+): Black.
      - b) Negative (-): Red.
      - c) Signal: White.
  - g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:

- 1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
- 2. Readily identified without twisting the conductor.



- F. General wiring requirements:
1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
  2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
  3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
  4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
  5. Provide power surge protection for all control panels.
  6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
  7. Provide non-metallic ducts for routing and organization of conductors and cables:
    - a. Provide wiring separation plan.
    - b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
    - c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
      - 1) 120 VAC: Grey colored ducts.
      - 2) 24 VDC: White colored ducts.
  8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
    - a. Screw-on cable tie mounts.
    - b. Hammer-on cable-tie mounting clips.
    - c. Fingers of the nonmetallic duct.
  9. Wire ties:
    - a. No wire ties inside wire duct.
    - b. Use Panduit Cable tie installation tool, with tension control/cutoff.
    - c. Verify cut ends are cut flush filed smooth after installed.
  10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
  11. Support panel conductors where necessary to keep them in place.
  12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
  13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    - a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
  14. The control panel shall be the source of power for all 120-VAC devices interconnected with the control panel including, but not limited to:
    - a. Solenoid valves.
    - b. Instruments both mounted in the control panel and remotely connected to the control panel.
- G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams Indicated on the Drawings or as specified.



## 2.06 EQUIPMENT (NOT USED)

## 2.07 COMPONENTS

### A. Thermal management:

1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
2. Air conditioner:
  - a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interfaces, panel instruments, programmable logic controllers, or remote I/O.
  - b. Provide filters on intake and exhaust openings.
  - c. Increase panel sizes as needed to accommodate cooling units.
  - d. Enclosure rating: NEMA Type 4X.
  - e. Closed-loop design.
  - f. Power supply: 120 VAC.
  - g. Manufacturers: The following or equal:
    - 1) Kooltronic, GuardianX DP Series.
    - 2) ICEcube, Blade series or IECEx/ATEX for Zone 1 & 2.
3. Heating:
  - a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
    - 1) The panel is not supplied with 120 VAC power.
    - 2) There are no electronics or moisture-sensitive devices in the enclosure.
    - 3) The panel is smaller than 38 inches high.
4. Heat exchanger:
  - a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
  - b. Filterless design to facilitate easy cleaning of the core.
  - c. Mounting: As indicated on the Drawings.
  - d. Manufacturers: The following or equal:
    - 1) Noren, CC Series.
    - 2) ICEcube, Blade series.
5. Enclosure temperature switch:
  - a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
  - b. Sensor and electronic enclosure.
  - c. Accuracy: Within 2 degrees Fahrenheit.
  - d. Single contact:
    - 1) Manufacturers: One of the following or equal:
      - a) nVent/Hoffman ATEMNC.
      - b) Pfannenberger FLZ.
  - e. Dual contact:
    - 1) Manufacturers: The following or equal:
      - a) nVent/Hoffman ADLTEMP.



6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
  - a. Provide as indicated on the Drawings or as specified.
7. Fan ventilation:
  - a. Provide nVent/Hoffman fan speed control:
    - 1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
    - 2) Provide finger-guard kit.
    - 3) Filter kit with 2 spare filters for each intake fan.
    - 4) Provide bezel and gasket kit.
    - 5) Provide fan shroud.
    - 6) Automatically adjust fan speed depending on remote temperature sensor input.
    - 7) 120 VAC, 60 hertz.
    - 8) NEMA Type 5-15R cord connections.
- B. Pilot devices:
  1. General:
    - a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
    - b. Size:
      - 1) 30.5 millimeters.
    - c. Heavy duty.
    - d. Pushbuttons:
      - 1) Contacts rated:
        - a) NEMA Type A600.
      - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
    - e. Selector switches:
      - 1) Contacts rated:
        - a) NEMA Type A600.
        - b) Knob type.
      - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
      - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
    - f. Pilot lights:
      - 1) Type:
        - a) LED for interior installations.
      - 2) Push to test.
      - 3) Lamp color:
        - a) On/Running/Start: Red.
        - b) Off/Stop: Green.
        - c) Power: White.
        - d) Alarm: Amber.
        - e) Status or normal condition: White.
        - f) Opened: Red.
        - g) Closed: Green.
        - h) Failure: Red.
  2. Indoor and outdoor areas:
    - a. NEMA Type 4/13.
    - b. Manufacturers: One of the following or equal:



- 1) Allen-Bradley, Type 800T.
    - 2) Schneider Electric, Class 9001, Type K.
    - 3) General Electric, Type CR104P.
    - 4) IDEC, TWTD Series.
  3. Corrosive areas:
    - a. NEMA Type 4X.
    - b. Corrosion resistant.
    - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
    - d. Manufacturers: One of the following or equal:
      - 1) Cutler Hammer, Type E34.
      - 2) Schneider Electric, Class 9001, Type SK.
      - 3) Allen-Bradley Type 800H.
      - 4) IDEC, TWTD Series.
  4. Hazardous (Classified) Areas/Class I Division 2:
    - a. NEMA Type 4X.
    - b. Corrosion resistant.
    - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
      - 1) All contacts contained within a hermetically sealed chamber:
        - a) Pushbuttons.
        - b) Selector switches.
        - c) Push-to-test contacts on pilot lights.
      - 2) UL listed and labeled for Class I Division 2 areas.
    - d. Manufacturers: One of the following or equal:
      - 1) Cutler Hammer, Type E34.
      - 2) Allen-Bradley, Type 800H.
  5. Hazardous (Classified) Areas/Class I Division 1:
    - a. Corrosion resistant.
    - b. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
      - 1) All contacts contained within a hermetically sealed chamber:
        - a) Pushbuttons.
        - b) Selector switches.
        - c) Push-to-test contacts on pilot lights.
      - 2) UL listed and labeled for Class I Division 1 areas.
    - c. Manufacturers: One of the following or equal:
      - 1) Cutler Hammer, Type E34.
      - 2) Allen-Bradley, Type 800H.
- C. Signal isolators and converters:
  1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    - a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
    - b. Adjustable span and zero.
    - c. Accuracy: Within 1.0 percent of span.
    - d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
  2. Manufacturers: One of the following or equal:
    - a. Phoenix Contact, Mini Analog Pro.
    - b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
    - c. Action Instruments, Q500 Series or Ultra SlimPakII.



- d. AGM Electronics, Model TA-4000.
- e. Moore Industries, MIT 4-Channel.

D. Relays:

- 1. General:
  - a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
  - b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
  - c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
- 2. General purpose:
  - a. Magnetic control relays.
  - b. NEMA ratings:
    - 1) 300 volts.
    - 2) 10 Amps thermal continuous test current.
    - 3) 60 Amps make.
    - 4) 6 Amps break.
  - c. Plug-in type.
  - d. LED indication for energization status.
  - e. Coil voltages: As required for the application.
  - f. Minimum poles: DPDT.
  - g. Touch-safe design: All connection terminals to be protected against accidental touch.
  - h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
  - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
  - j. Relays with screw-type socket terminals.
  - k. Provide additional (slave/interposing) relays when the following occurs:
    - 1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
    - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
  - l. DIN rail mounting on 35-millimeter rail.
  - m. Ice-cube-type relays with retainer clips to secure relay in socket.
  - n. Integrated label holder for device labeling.
  - o. Manufacturers: One of the following or equal:
    - 1) Potter and Brumfield: Type KRP or KUP.
    - 2) IDEC: R\* Series (\* = H, J, R, S, U).
    - 3) Allen-Bradley: Type 700 HC.
    - 4) Square D: Type K.
- 3. Terminal block relays:
  - a. Magnetic control relays.
  - b. For use as an interposing relay for PLC based discrete I/O signals.
  - c. NEMA ratings:
    - 1) 250 volts.
    - 2) 6 Amps continuous.
    - 3) 1,500 volt-amperes make.
  - d. Plug-in type.
  - e. LED indication for energization status.
  - f. Coil voltages: As required for the application.
  - g. Minimum poles: SPDT.





- h. Touch-safe design: All connection terminals to be protected against accidental touch.
- i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
- j. Relays with screw-type socket terminals.
- k. DIN rail mounting on 35-millimeter rail.
- l. Integrated label holder for device labeling.
- m. Manufacturer: One of the following or equal:
  - 1) Phoenix Contact PLC Series.
  - 2) Eaton XR TBR Series.
  - 3) IDEC RV8H Series.
  - 4) Allen-Bradley Type 700 HL TBR Series.
- 4. Latching:
  - a. Magnetic-latching control relays.
  - b. NEMA ratings:
    - 1) 300 volts.
    - 2) 5 Amps continuous.
    - 3) 360 volt-amperes make.
    - 4) 320 volt-amperes break.
  - c. Plug-in type.
  - d. DIN rail mounting on 35-millimeter rail.
  - e. Coil voltage: As required for the application.
  - f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
  - g. Touch-safe design: All connection terminals to be protected against accidental touch.
  - h. Clear cover for visual inspection.
  - i. Provide retainer clip to secure relay in socket.
  - j. Manufacturers: One of the following or equal:
    - 1) Square D, 8501, Type K.
    - 2) IDEC, RR2KP Series.

E. Terminal blocks:

- 1. DIN rail mounting on 35-millimeter rail.
- 2. Rated for 15 amperes at 600 volts.
- 3. Screw terminal type.
- 4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
- 5. Finger-safe protection for all terminals for conductors.
- 6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
- 7. Terminals: Plainly identified to correspond with markings on the diagrams:
  - a. Permanent machine-printed terminal identification.
- 8. Disconnect-type field signal conductor terminals with socket/screw for testing.
- 9. Identify terminals suitable for use with more than 1 conductor.
- 10. Position:
  - a. So that the internal and external wiring does not cross.
  - b. To provide unobstructed access to the terminals and their conductors.
- 11. Provide minimum 25-percent spare terminals.
- 12. Manufacturers: One of the following or equal:
  - a. Phoenix Contact, UT4 Series.
  - b. Allen-Bradley, 1492 Series.





- F. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
    - a. Mount to DIN rail via grounding foot with mounting screw.
    - b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
    - c. Not be used for grounding signal cable shields.
  2. Screw terminal type.
  3. DIN rail mounting on 35-millimeter rail.
  4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
  5. Finger-safe protection for all terminals for conductors.
  6. Terminals: Plainly identified to correspond with markings on the diagrams:
    - a. Permanent machine-printed terminal identification.
  7. Manufacturers: One of the following or equal:
    - a. Phoenix Contact, USKLG Series.
    - b. Allen-Bradley, 1492-JG Series.
- G. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
  2. Type:
    - a. Wide slot.
    - b. Narrow slot.
    - c. Round hole.
  3. Manufacturers: The following or equal:
    - a. Panduit.
    - b. Phoenix Contact.
    - c. Thomas & Betts.
    - d. Iboco.
- H. DIN rail:
1. Perforated steel.
  2. 35 mm width.
  3. 15 mm deep.
  4. Provide 2-inch offset using one of the following:
    - a. Offset brackets.
    - b. Preformed standoff DIN Rail Channel.
- I. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
    - a. Provide SPD for panel 120 VAC power entrances:
      - 1) Non-faulting and non-interrupting design.
      - 2) Provide line to neutral and neutral to ground surge protection.
    - b. Provide surge protection at secondary of main circuit breaker:
      - 1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
      - 2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
    - c. DIN rail mounting.
    - d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:



- 1) Gastight connections.
    - 2) Visual status indication of MOV status on the input and output circuits.
    - 3) Dry contact rated for remote status indication.
  - e. Approvals:
    - 1) Tested in accordance with IEC 61643-11.
    - 2) Tested in accordance with UL 1283.
    - 3) Tested in accordance with UL 1449.
    - 4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20  $\mu$ s waveform in accordance with IEEE C62.41.1 Category C Area.
  - f. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, Type SFP Filter.
    - 2) ASCO, Model 277.
2. 24 VDC control panel power SPD:
  - a. Provide SPD for 24VDC power circuits.
  - b. Provide surge protection at DC power supply output.
  - c. DIN rail mounting.
  - d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
    - 1) Optical status indicator.
    - 2) Dry contact rated for remote status indication.
  - e. Approvals:
    - 1) Tested in accordance with IEC 61643-11.
  - f. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, Plugtrab PLT-SEC-T3-24-FM-UT.
3. Panel mounted control, signal, and data line SPD:
  - a. General:
    - 1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
    - 2) Approvals:
      - a) Tested in accordance with IEC 61643-21.
      - b) Tested in accordance with UL 497B.
    - 3) SPD shall consists of 2 parts:
      - a) Base module:
        - (1) DIN rail mounting.
        - (a) Grounded to DIN rail via mounting rail foot.
      - b) Plug protection module:
        - (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
    - 4) Provide indirect shield ground style SPD unless otherwise noted.
    - 5) Provide ability to locally identify and indicate SPD health.
    - 6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
    - 7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
    - 8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.
  - b. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, Plugtrab PT-IQ Series.
    - 2) Dehn, Blitzductor XTU Series.
4. Copper Ethernet SPD:



- a. Protects network equipment from lightning or other surge events.
  - b. Suitable for Gigabit networks.
  - c. Compatible with shielded Cat 6 cabling with shielded RJ-45 ports.
  - d. Compliant with PoE standards IEEE 802.3af and 802.3at.
  - e. Nominal discharge surge current: 10 kA.
  - f. Approvals:
    - 1) Tested in accordance with IEC 61643-21.
    - 2) Tested in accordance with UL 497B.
  - g. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, DT-LAN-CAT6+.
    - 2) Weidmuller, VDATA CAT6.
    - 3) Eaton/MTL, ZoneBarrier.
5. Field device mounted SPD:
- a. Conduit entry mounting.
    - 1) Provide parallel or through wiring configurations as required by the application.
      - a) Use parallel wiring configuration if there is an available cable gland at the device.
      - b) Use through wiring configuration if there is no available cable gland at the device.
    - 2) Provide Screw connections compatible with field device.
  - b. NEMA 4X 316 stainless steel material housing.
  - c. Approvals:
    - 1) Tested in accordance with IEC 61643-21.
  - d. 4-wire field device:
    - 1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
      - a) Maximum continuous voltage:
        - (1) DC:
          - (a) Signal: 32 VDC.
          - (b) Power supply: 255 VDC.
        - (2) AC:
          - (a) Signal: 22.6 VAC.
          - (b) Power supply: 255 VAC.
      - 2) Manufacturers: The following, engineer knows of no equal:
        - a) Endress+Hauser, HAW569-CB2C.
  - e. 2-wire or 3-wire field device:
    - 1) Module shall provide protection for the signal cable, communication bus or data line.
    - 2) Manufacturers: One of the following or equal:
      - a) Endress+Hauser, HAW569 Series.
      - b) Phoenix Contact, Surgetrab S-PT Series.
      - c) Eaton/MTL, TP Series.
- J. Power supplies:
- 1. Design power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
  - 2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
  - 3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.



4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
  - a. Provide automatic switchover upon module failure.
  - b. Alarm contacts monitored by the PLC.
5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
6. Sized to provide 40-percent excess rated capacity.
7. UL 508C listed to allow full-rated output without de-rating.
8. Provide fuse or short-circuit protection.
9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
12. Touch-safe design: All connection terminals to be protected against accidental touch.
13. DIN rail mounting on 35-millimeter rail:
  - a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
15. Manufacturers: One of the following or equal:
  - a. Fully redundant:
    - 1) Phoenix Contact, Quint Power Supply with SFB technology.
      - a) Phoenix Contact, Quint.
    - 2) IDEC, PS5R Series:
    - 3) Sola.
    - 4) PULS.
  - b. Redundancy module:
    - 1) Phoenix contact, o-ring redundancy module.

## 2.08 ACCESSORIES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.
- D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- E. Provide nameplate to each panel as indicated on the Drawings:



1. Provide as specified in Section 16075 - Identification for Electrical Systems on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
  - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
  - b. Supply voltage, phase, frequency, and full-load current.
  - c. Power source or circuit ID.
  - d. Short-circuit current rating of the panel based on one of the following:
    - 1) Short-circuit current rating of a listed and labeled assembly.
    - 2) Short-circuit current rating established utilizing an approved method.
- F. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. The window shall meet the following requirements:
  1. Safety plate glass.
  2. Secured by rubber locking seal.
  3. Allow full viewing of devices issuing visual process data or diagnostics.
- G. Lighting:
  1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    - a. Covered or guarded.
    - b. Provide On-Off door-activated switches where indicated on the Drawings.
    - c. 120-volt, single-phase, 15-amp style plug.
    - d. Provide 4,000 K, 900 Lumens - LED fixture.
      - 1) Provide additional fixtures for every 36 inches of width.
- H. Receptacles:
  1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
  2. GFCI, 120-volt, single-phase, 15-amp style plug.
  3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.
- I. Grounding:
  1. Provide the following:
    - a. Grounding strap between enclosure doors and the enclosure.
    - b. Equipment grounding conductor terminals.
    - c. Provide equipment grounding busbar with lugs for connection of all equipment grounding wires.
    - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
  2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND," the letter "G," or the color green.
  3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
  4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
  5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
  6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.



7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Unless otherwise noted, connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.

J. Provide sunshades and insulation for all outdoor installations.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES**

### **A. Finishes:**

1. Metallic (non-stainless):
  - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
  - b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
  - c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
  - d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
  - a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

### **B. Colors:**

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

## **2.12 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

### **3.02 PREPARATION (NOT USED)**



### 3.03 INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
- B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.
- D. Provide concrete housekeeping pads for freestanding enclosures.
  - 1. Refer to the structural typical details.
- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
  - 1. Undercoat floor-mounted panels.
- F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.
- G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.
- H. Protect all wiring from sharp edges and corners.
- I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the Loop Drawings prepared by the Contractor.
- J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.
- K. Side panels:
  - 1. Side panels shall be kept free off all control equipment and devices. Any deviation must be sent to the engineer in writing asking for a deviation.

### 3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

### 3.05 REPAIRS/RESTORATION (NOT USED)

### 3.06 RE-INSTALLATION (NOT USED)

### 3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### 3.08 ADJUSTING (NOT USED)





### **3.09 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.10 DEMONSTRATION AND TRAINING (NOT USED)**

### **3.11 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17720

### CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Programmable logic controller (PLC) based control systems hardware.
  - 2. Development software to be used with the specified PLC hardware.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE).

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. CPU: Central processing unit.
  - 2. I/O: Input/Output.
- C. Specific definitions:
  - 1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
  - 2. Application software: The software that is programmed specifically for the Project.

##### 1.04 SYSTEM DESCRIPTION

- A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
  - 1. CPU:
    - a. Processor type.
    - b. Processor speed.
    - c. Memory.
    - d. Internal processor battery backup time.



2. I/O modules:
  - a. Type.
  - b. Standard wiring diagram.
- C. Calculations:
  1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
  2. Submit calculations to verify that spare I/O requirements of this Section are met.
  3. Submit calculations to verify that PLC power supply requirements of this Section are met.
- D. Product data:
  1. Programming languages.
  2. Operating system requirements.
- E. Control logic:
  1. Fully annotated copy of programmed PLC logic.
  2. Cross-referenced index of all PLC registers or points.
- F. Provide application software for the specific Project process requirements.
  1. Fully annotated copy of programmed PLC logic in its native format.
  2. Cross-referenced index of all PLC registers or points.

#### **1.06 QUALITY ASSURANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.
- C. Additional requirements:
  1. Provide PLC system components by a single manufacturer:
    - a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
  2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
  3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.12 SYSTEM START-UP (NOT USED)**

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 COMMISSIONING (NOT USED)**

## **1.15 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. In addition to the spare parts requirements specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems
  - 1. CPU: 1 spare for each type of CPU in the system.
  - 2. I/O cards: 3 spares for each type of I/O card in the system.
  - 3. Power supplies: 2 spares for every power supply in the system.
  - 4. Network/communications cards: 1 spare for every network or communications card in the system.
  - 5. Remote adaptor: 1 spare for every remote adaptor in the system.
  - 6. Chassis: 1 spare for each chassis size in the system.
  - 7. Communication cable: 1 spare for each type of cable used in the system.
- C. Installed spare requirements:
  - 1. I/O points:
    - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
    - b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
  - 2. PLC backplane capacity:
    - a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
  - 3. PLC memory:
    - a. Provide 50-percent spare program volatile memory.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Rockwell Automation:
    - a. CompactLogix.
  - 2. Modicon:
    - a. M580.



- b. Momentum.
    - c. M340.
  - 3. General Electric:
    - a. RX3i.
    - b. VersaMax.
    - c. VersaMax Micro.
- B. The PLC programming software system shall be manufactured by PLC hardware manufacturer:
  - 1. Rockwell Software:
    - a. RSLogix 5000.
    - b. Studio 5000.
  - 2. Modicon:
    - a. Unity Pro.
  - 3. General Electric, Proficy Machine Edition with Logic Developer - PLC.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS**

- A. Programmable logic controller:
  - 1. Construction:
    - a. Furnish plug-in modular system.
    - b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
      - 1) Temperature: 0 to 60 degrees Celsius.
      - 2) RFI: 80 to 1,000 MHz.
      - 3) Vibration: 10 to 500 hertz.
      - 4) Humidity: 0 to 95 percent.
    - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
    - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
      - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
  - 2. CPU:
    - a. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
    - b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
    - c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.



3. Memory:
  - a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
  - b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
    - 1) Reserve capacity:
      - a) Totally free from any system use.
    - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
4. Programming:
  - a. Provide a system where processors are programmed by:
    - 1) Portable laptop computer both locally and via the PLC control network.
5. PLC power supply:
  - a. Input: 120 VAC.
  - b. Mounted in the PLC housing or as indicated on the Drawings.
  - c. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
6. PLC input/output, I/O modules:
  - a. General:
    - 1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
    - 2) Provide I/O modules that:
      - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
      - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
      - c) Accept dual-ended inputs.
    - 3) The use of common grounds between I/O points is not acceptable.
    - 4) Provide modules that are removable without having to disconnect wiring terminals:
      - a) Utilize a swing-arm or plug-in wiring connector.
    - 5) Provide at each PLC the I/O modules for the following:
      - a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
      - b) Installed spare capacity in accordance with the requirements of this Section.
      - c) Wire all spares provided to the field terminal strip.
    - 6) Condition, filter, and check input signals for instrument limit conditions.
    - 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
    - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
    - 9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.



- 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
- b. Discrete input modules:
  - 1) Defined as contact closure inputs from devices external to the input module.
  - 2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
  - 3) Individually isolated inputs.
  - 4) With LEDs to indicate status of each discrete input.
- 1) Input voltage: 120VAC.
- 2) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
  - a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.
- c. Discrete output modules:
  - 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
    - a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
  - 2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
  - 3) LEDs to indicate status of each output point.
  - 4) Output voltage: 120VAC.
  - 5) Individually isolated outputs.
- d. Analog input modules:
  - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
  - 2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
  - 3) The analog-to-digital conversion updated with each scan of the processor.
  - 4) Individually isolated each input.
  - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
- e. Analog output modules:
  - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
  - 2) Individual isolated output points each rated for loads of up to 1,000 ohms.
- f. Specialty I/O modules:
  - 1) Resistance temperature detector (RTD) input module:
    - a) Channels per module: 4 minimum.
    - b) RTD types accepted:
      - (1) 100-ohm platinum.



- (2) 200-ohm platinum.
        - (3) 500-ohm platinum.
        - (4) 1,000-ohm platinum.
        - (5) 100-ohm nickel.
        - (6) 200-ohm nickel.
        - (7) 500-ohm nickel.
        - (8) 10-ohm copper.
      - c) Provide input module that accepts 2-, 3-, or 4-wire RTD.
    - g. Network communications modules:
      - 1) General:
        - a) Install communications modules in the PLC backplane.
      - 2) Ethernet:
        - a) Ports: 1RJ-45.
        - b) Communication rate: 100 Mbit/s.
      - 3) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
  7. PLC backplane housing:
    - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
    - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
    - c. Provide a blank slot filler module for each spare slot.
- B. PLC programming software:
1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
    - a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
    - b. Monitor devices at each drop on the PLC data network for proper communications.
    - c. Provide the ability to program all PLCs on the PLC data network from the Engineer's console.
  2. PLC programming laptop/desktop operating system:
    - a. Microsoft Windows 10.
  3. The PLC programming software shall be suitable for the PLCs specified above.
  4. PLC programming software for all programming, monitoring, searching, and editing:
    - a. Usable both on-line, while connected to the PLC, and off-line.
    - b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
    - c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
    - d. Include a search capability to locate any address or element and its program location.
    - e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
  5. The PLC programming software shall support the following programming languages:
    - a. Ladder Diagram.





6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
  - a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
  - b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
  - c. Use a mnemonic associated with each contact, coil, etc. that describes its function.
  - d. Utilize the tag and loop identification as contained in the P&IDs:
    - 1) If additional internal coils, timers, etc. are used for a loop, they shall contain the loop number.
  - e. Provide a cross-reference report of program addresses.
7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
  - a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
    - 1) Respond to demands from a program request.
    - 2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
    - 3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
    - 4) Queuing of requests in order of priority if one or more requested resources are unavailable.
    - 5) Resolution of contending requests for the same resource in accordance with priority.
    - 6) Service requests for execution of one program by another.
    - 7) Transfer data between programs as requested.
    - 8) Management of all information transfers to and from peripheral devices.
    - 9) Control and recovery from all program fault conditions.
    - 10) Diagnose and report real-time hardware device errors.
8. Program execution:
  - a. Application software - program execution scheduled on a priority basis:
    - 1) A multilevel priority interrupt structure is required.
    - 2) Enter into a list of pending programs a program interrupted by a higher priority program:
      - a) Resume its execution once it becomes the currently highest priority program.
    - 3) Schedule periodic programs.
    - 4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
9. Start-up and restart:
  - a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
  - b. Initialization:
    - 1) Determination of system status before start-up of initializing operating system software and initializing application software.



- 2) Loading of all memory-resident software, initializing timers, counters and queues, and initialization of all dynamic database values.
10. Shutdown:
  - a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
  - b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
  - c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
  - d. Alarm PLC failure at the operator interface level.
11. Diagnostics:
  - a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
  - b. Use the manufacturer's standard diagnostic routines as much as possible.
  - c. Furnish diagnostic software and test programs for each significant component in the control system.
  - d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
12. Calendar/time program:
  - a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system-level and application software.
  - b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
  - c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
  - a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
  - b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
  - c. Algorithms must include alarm checks where appropriate.
  - d. Provide, as a minimum, the following types of algorithms:
    - 1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
    - 2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
    - 3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
    - 4) Lead, lag, dead time, and ratio compensators.
    - 5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
  - a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.



16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:
  - a. Analog input signal types:
    - 1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
  - b. Input accuracy:
    - 1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
    - 2) Data conversion errors must be less than 0.05-percent full-scale.
    - 3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
    - 4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
  - c. Blocking:
    - 1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
    - 2) For any input so blocked, the operator may manually enter a value to be used as the input value.
  - d. Filtering:
    - 1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
  - e. Linearizing:
    - 1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
  - f. Calculated values:
    - 1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
    - 2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
  - g. Scaling and zero suppression:
    - 1) Provide a conversion program to convert input values into engineering units in a floating-point format.
  - h. Alarms:
    - 1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
    - 2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
    - 3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
    - 4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.



- i. Averages:
  - 1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
  - 2) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
  - 3) Update hourly averages each minute or at the polling interval for the selected variable.
  - 4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
  - 5) Update monthly averages at least once each day and calculate using the results of the daily averages.
  - 6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
  - 7) The active database must include the present period average and previous period average for each variable and averaging period.
- j. Totals:
  - 1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
  - 2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
  - 3) Assign a separate factor for each totalizing interval.
  - 4) Variables for which totalization is inappropriate must have scaling factors of zero.
  - 5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
  - 6) The active database must include the present period total and previous period total for each variable and totalizing period.
- k. Engineering units:
  - 1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
  - 2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
  - 3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
  - 4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
  - 5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.
- l. Control modules:
  - 1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
  - 2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.



- 3) Provide control algorithms for manual control with output values adjustable by the operator.
  - m. Analog outputs:
    - 1) Analog outputs must be maintained as part of the database.
    - 2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.
  18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.
- C. General control functions:
1. Analog control functions:
    - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
    - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
    - c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
    - d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
  2. Discrete control functions:
    - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
  3. Software support:
    - a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
    - b. Call each function as required by the configured controls to perform the intended function.
  4. Control and status discrepancies:
    - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
      - 1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
    - b. Involuntary change in the device's status must also generate an alarm:
      - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
    - c. Each command, status, and alarm must cause the color of the symbol to change.
    - d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
      - 1) Delay periods for each final control element must be adjustable at the operator interface.
      - 2) List all time delays in the final documentation.



5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. Control configuration:

1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.
2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints, tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

**2.05 EQUIPMENT (NOT USED)**

**2.06 COMPONENTS (NOT USED)**

**2.07 ACCESSORIES (NOT USED)**

**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**

**3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:





1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. General:
  1. The control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- F. Program the PLC logic using the following language(s):
  1. Ladder Diagram.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION**

- A. Provide a minimum of 4 CD/DVD copies of the following:
  1. Application software:
    - a. Finalized fully annotated copy of programmed PLC logic in its native format.
    - b. Cross-referenced index of all PLC registers or points.

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.08 ADJUSTING (NOT USED)**

#### **3.09 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.10 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.
- C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
  1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer's training course for the PLC hardware.



2. A representative of the ICSC may perform the PLC programming software training only if the representative has completed the manufacturer's training course for the PLC programming software.

### **3.11 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17733

### CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Materials and equipment used in process control and LAN networks including:
    - a. Network switches.
    - b. Media converters.
    - c. Routers.
    - d. Patch panels and other data network hardware.
    - e. Related accessories.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 802.1X – Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
  - 2. 802.3 - Standard for Ethernet.
  - 3. 802.3ab - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T.
  - 4. 802.3u - Standards for Local and Metropolitan Area Networks: Supplement - Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BASE-T (Clauses 21-30).
  - 5. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
- C. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
  - 1. 568-C.3 - Optical Fiber Cabling Components Standard.
- D. Underwriters Laboratories, Inc. (UL).

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



04

## SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
  - 1. Include information on all network equipment.
  - 2. Manufacturer's operation and installation instructions.
- C. Shop drawings:
  - 1. Complete set of drawings including but not limited to:
    - a. System block diagram showing relationship and connections between devices provided under this Contract **and existing equipment**. Include manufacturer and model information, and address settings.
    - b. Network riser diagram.
    - c. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
    - d. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, and nameplates.
    - e. Electrical connection diagrams.
    - f. Complete grounding requirements.
  - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
    - a. Manufacturer's model number.
    - b. Project equipment tag.
  - 3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
    - a. Quantity.
    - b. Description.
    - c. Manufacturer.
    - d. Part numbers.
- D. Test reports:
  - 1. As specified in Sections:
    - a. 16125 - Fiber Optic Cable and Appurtenances.
    - b. 17950 - Commissioning for Instrumentation and Controls.
  - 2. Signed test results as described in this Section.
  - 3. Test results shall include:
    - a. Narrative describing the test procedures followed.
    - b. Block diagram of test set up.
    - c. Manufacturer's information on test equipment used.
    - d. Detailed test results.
    - e. A narrative summarizing the results of the testing and identifying any further action required.
- E. Operating manuals:
  - 1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



- F. Record drawings:
1. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

#### **1.05 QUALITY ASSURANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.08 SEQUENCING (NOT USED)**

#### **1.09 SCHEDULING (NOT USED)**

#### **1.10 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.11 SYSTEM START-UP (NOT USED)**

#### **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.13 COMMISSIONING (NOT USED)**

#### **1.14 MAINTENANCE (NOT USED)**

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS (NOT USED)**

#### **2.02 SYSTEM DESCRIPTION**

- A. Provide all network equipment identified in the Contract Documents.

#### **2.03 EXISTING PRODUCTS (NOT USED)**

#### **2.04 MATERIALS (NOT USED)**



05

## MANUFACTURED UNITS

- A. Unmanaged Ethernet switches:
  - 1. Manufacturers: One of the following or equal:
    - a. Moxa, 308/305 Series.
    - b. N-Tron.
    - c. Hirschmann.
  - 2. Properties:
    - a. Hardware:
      - 1) 10/100BASE-FX.
      - 2) 100BASE-FX.
      - 3) Power supply:
        - a) Provide redundant power supplies.
        - b) 24 VDC, 200 watts/per power supply.
        - c) Store and forward.
      - 4) No fans or moving parts.
    - b. Performance:
      - 1) Full/half-Duplex.
      - 2) MDI/MDI-X Auto-sensing.
    - c. Environment:
      - 1) Operating temperature range: 32 to 140 Degrees Fahrenheit.
      - 2) Humidity: 5 to 95 percent, non-condensing.
    - d. The Ethernet switch shall be capable of performing basic switching without special programming or configurations.
    - e. Ports:
      - 1) As required to provide the number of connections required plus 10 percent spare of each type used.
    - f. Connector type:
      - 1) Fiber: SC.
      - 2) Copper: RJ-45.
    - g. Mounting:
      - 1) Din Rail.
- B. Media converters:
  - 1. Copper to fiber transceiver:
    - a. Manufacturers: One of the following or equal:
      - 1) N-Tron.
      - 2) Transition Networks.
      - 3) Phoenix Contact.
    - b. Transceiver shall be used to convert from Half/Full Duplex Ethernet to multimode fiber Ethernet 100BASE-FX:
      - 1) Meets requirements of IEEE 802.3 Ethernet standard.
      - 2) Supports Half/Full Duplex.
      - 3) Connector type:
        - a) Fiber: SC.
        - b) Copper: RJ-45.
      - 4) Power supply:
        - a) 110 VAC, 60 hertz.
        - b) 24 VDC, 6 watts.
      - 5) Mounting:
        - a) Provide mounting hardware.
        - b) DIN rail mounting, unless otherwise indicated on the Drawings.



C. Patch panels:

1. General:

a. Fiber:

- 1) All optical fibers shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via fiber optic patch cords.
- 2) All fibers, active and dark, shall be terminated at the patch panels.
- 3) Interconnect and patch panel housings shall provide space for excess fiber and provide strain relief for the fiber cable.
- 4) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.

b. Copper:

- 1) Final connections between the patch panel and network equipment shall be by patch cords.
- 2) All premises cables shall be terminated at the patch panels.
- 3) Cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out conductors.
- 4) Maintain twist of broken out conductors per EIA/TIA standards.

2. Cabinet style fiber patch panels:

a. DIN rail mounted:

- 1) Use for the termination of a single cable inside of cabinets, in small enclosures or as indicated on the plans.
- 2) DIN rail mounted cable interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
- 3) DIN rail mounted cable interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
- 4) Capacity:
  - a) As shown on the plans, minimum 6 connections.
- 5) Accessories:
  - a) Blanks for unused connector panels.
- 6) Manufacturers: One of the following or equal:
  - a) Hirschmann, MIPP.
  - b) DINSpace, SNAP XL.

**2.06 EQUIPMENT (NOT USED)**

**2.07 COMPONENTS (NOT USED)**

**2.08 ACCESSORIES**

- A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.
- B. Furnish accessories as specified in Section 17730 - Control Systems: PCS Computer Equipment.

**2.09 MIXES (NOT USED)**

**2.10 FABRICATION (NOT USED)**



## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section:
  - 1. Refer to SCADA block diagrams for all new network connections.
  - 2. Provide configuration for all managed Ethernet switches and other components including but not limited to VLAN (virtual local area network), additional Plant PLC communication cards and separate managed Ethernet switches as required, such that there is isolation of the following networks:
    - a. Field and PLC I/O network: This includes the connections between the Plant PLC and:
      - 1) Plant PLC expansion racks.
      - 2) Plant PLC remote I/O (RIO) racks.
      - 3) Field Networks.
      - 4) HMI(s) part of a Plant PLC.
      - 5) Vendor furnished Ethernet network components.
    - b. Valve Actuator network: This includes the connections between the Plant PLC and the valve master stations.
    - c. Process Control network: This includes the connections between the Plant PLC and other Plant PLCs.
    - d. SCADA network: This includes the connections between the various SCADA equipment including but not limited to servers (existing), workstations and printers.
    - e. Security network: This includes any security hardware with Ethernet communication as provided by the security/telephone/internet sub-contractor.
  - 3. The process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
  - 4. The enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.
- C. All racks shall be level and plumb.
- D. Install Velcro wrap on all cable bundles within the network rack/enclosure.



- E. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
  - 1. Cables shall be installed avoiding sharp bends.
  - 2. Install cable using lubricant designed for cable pulling.
  - 3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
  - 4. Install LAN cables without splices.
  - 5. Installed bend radii shall not exceed 4 times the cable diameter.
  - 6. Terminated all pairs at the jack and the patch panel.
- F. Install cables a minimum of 40 inches away from electrical motors and transformers.
- G. Install cables a minimum of 12 inches away from fluorescent lighting.
- H. Individual pairs will be untwisted less than 1/2-inch at termination points.
- I. All cables and terminations shall be labeled with cable designations as specified in Section 16075 - Identification for Electrical Systems.
- J. Each data port shall be individually labeled with its patch panel/switch port ID:
  - 1. Labeling must be printed - no handwritten labels will be allowed.
- K. At the completion of the wiring installation, provide the following documentation:
  - 1. A plan-view of the premise(s) showing the jack numbering scheme.
  - 2. A printed certification report for the entire wiring installation showing compliance with all EIA/TIA specifications for data cable.
  - 3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
  - 4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 FIELD QUALITY CONTROL (NOT USED)**

#### **3.08 ADJUSTING**

- A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

#### **3.09 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.





3.10

## **DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.
- C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

### **3.11 PROTECTION (NOT USED)**

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION



## **SECTION 17950**

### **COMMISSIONING FOR INSTRUMENTATION AND CONTROLS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

##### **1.02 REFERENCES**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Electronics Industries Alliance (EIA).
- C. Telecommunications Industry Association (TIA).

##### **1.03 DEFINITIONS**

- A. As specified in Sections 01756 - Commissioning and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
  - 2. Loop Validation Tests - Signals are tested from the field device to the PLC.
  - 3. Platform Testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.
  - 4. PTO: Profibus Trade Organization.

##### **1.04 SYSTEM DESCRIPTION (NOT USED)**

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures.
- B. General:
  - 1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Overall test plan:
  - 1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.



2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
  3. Describe the test phases as they apply specifically to this Project and each process system.
  4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
  5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
  6. Provide examples of proposed forms and checklists.
- D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
  2. Provide a statement of test objectives for each test.
  3. Prepare specific procedures for each process system.
  4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
  5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
  6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
  7. Provide the forms and checklists to be used.
- E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
    - a. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
    - b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
    - c. Sample test forms at the end of this Section show the minimum required content.
      - 1) The sample test forms have not been customized for this Project.
      - 2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.
- F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
    - a. Control system testing block diagram.
    - b. Estimated test duration.



- G. Details on the simulator construction, components, and operation. Testing binders:
1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
  2. Fill out in advance headings and all other information known before the test.
  3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
  4. Include or list reference material and provide separately at the time of the test.
  5. Record test results and verify that all test requirements and conditions have been met.
- H. Test reports:
1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
  2. Include all completed test binders, forms, and checklists.
  3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

#### **1.06 QUALITY ASSURANCE**

- A. Test personnel:
1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

#### **1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)**

#### **1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

#### **1.09 SEQUENCING (NOT USED)**

#### **1.10 SCHEDULING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.11 WARRANTY (NOT USED)**

#### **1.12 SYSTEM START-UP (NOT USED)**

#### **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.14 MAINTENANCE (NOT USED)**

### **PART 2 PRODUCTS (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**



## 3.02 PREPARATION (NOT USED)

### 3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Installation supervision:
  - 1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## 3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

## 3.05 REPAIR/RESTORATION (NOT USED)

### 3.06 COMMISSIONING

- A. Commissioning as specified in Section 01756 - Commissioning.
- B. Testing and training phase:
  - 1. Source testing:
    - a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
17100 - Control Strategies	Control Strategies	Witnessed
17101 - Specific Control Strategies	Specific Control Strategies	Witnessed
17710 - Control Systems - Panels, Enclosures, and Panel Components.	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
17950 – Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

- b. Prerequisite requirements:
  - 1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.
- c. Preliminary FAT (Pre-FAT):
  - 1) The purpose of the Pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality.
    - a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
    - b) Contractor shall fully test the HMI/SCADA system and fix all deficiencies found before the FAT.
  - 2) Conduct utilizing test procedures approved by Engineer



- 3) Owner shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
- 4) Submit a letter, signed by the Contractor's project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT.
  - a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.
- 5) Engineer approval of the pre-FAT submittal is required before proceeding to FAT.
- d. FAT hardware and communications testing:
  - 1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
  - 2) The complete PCIS system including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
  - 3) Testing simulation:
    - a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
    - b) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system.
      - (1) The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
      - (2) The simulator may consist of a PLC, operating under a HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
      - (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
  - 4) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
  - 5) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
  - 6) Verify communications between the hardware and the programmer's software comply with specified requirements.
    - a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio based telemetry systems.
  - 7) Panel inspections:
    - a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings.



- (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
  - b) Inspection forms:
    - (1) Provide panel inspection forms as part of the FAT procedures submittal.
    - (2) A sample FAT control panel form has been provided at the end of this Section.
- 8) I/O test:
  - a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
  - b) Test methodology:
    - (1) Discrete inputs:
      - (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
    - (2) Discrete outputs:
      - (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
    - (3) Analog inputs:
      - (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
      - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
    - (4) Analog outputs:
      - (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
      - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
  - c) Test forms to include, but not be limited to the following data:
    - (1) PLC and panel number.
    - (2) I/O type.
    - (3) I/O tag name.
    - (4) Rack/slot/number of I/O point.
    - (5) Check-off for correct response for each I/O point.
    - (6) Comments field.
    - (7) Initials of individual performing test.
    - (8) Date test was performed.
    - (9) Witness signature lines.
- 9) System configuration test:
  - a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.





- b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
  - c) Demonstrate the proper operation of peripheral hardware.
  - d) Demonstrate general HMI/SCADA functions.
  - e) Demonstrate proper operation of log-on and other security access functions.
  - f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
  - g) Test automatic fail over of redundant equipment.
  - h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
  - i) Test forms:
    - (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
    - (2) List the specific tests and steps to be conducted.
    - (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
      - (a) Include signature and date lines.
- 10) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
- e. FAT Platform Testing - Control logic test:
- 1) Verify the PLC, HMI and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
  - 2) Testing requirements:
    - a) Demonstrate each function described in the Control Strategies.
    - b) Demonstrate in detail how each function operates under a variety of operating scenarios.
      - (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
    - c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description.
      - (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
      - (2) Loops with similar or identical logic must each be tested individually.
      - (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
    - d) Demonstrate the proper operation of all digital communication links and networks.
      - (1) Verify each digital communication I/O point.
    - e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.





- 3) Test forms:
    - a) Submit completed test forms for each loop including but not limited to the fully revised and approved control strategy.
    - b) Identify the cause and effect as each I/O point is toggled through the simulator.
      - (1) Identify and track proper and/or improper operation of the loop.
    - c) Note any deficiencies or operational changes on the forms for correction and documentation:
      - (1) Include signature and date lines.
  - 4) Engineer approval of the FAT submittal is required prior to shipment of system components.
2. Owner training:
    - a. Demonstration requirements are specified in this Section.

Table 1			
Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	8	10	1
Operator Training - Basic	24	10	2
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PLC Hardware	16	4	1
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3. Installation testing:
  - a. Calibration:
    - 1) Performed by Contractor and ICSC.
    - 2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
  - 3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
    - a) Calibration for discrete devices:
      - (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.



- b) Calibration for ultrasonic and radar level devices:
    - (1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units.
      - (a) Submit printout of the actual transmission and parameters.
    - (2) Adjust mounting, as required, to obtain accurate readings.
    - (3) Post mounting: Provide any additional calibration required by manufacturer.
  - c) Calibrating analog transmitters:
    - (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
    - (2) Test and verify that components and/or systems are within the specified limits of accuracy.
    - (3) Calibration points:
      - (a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
    - (4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
  - d) Analyzer calibration:
    - (1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
    - (2) Submit completed instrument calibration sheets for every field instrument and analyzer.
    - (3) Calibration tags:
      - (a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
      - (b) Sign the tag when calibration is complete.
  - e) Calibration for industrial networking test equipment:
  - f) Submit calibration documentation.
- b. Loop check:
- 1) Performed by the Contractor.
  - 2) Cabling installed, terminated, and labeled.
  - 3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
  - 4) Complete loop check form for each device.
  - 5) Submit loop check test results before proceeding to the next step.
- c. Loop validation tests:
- 1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
  - 2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
    - a) The PLC may or may not be connected to the network.
  - 3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.



- d. Complete End-to-End Testing (CEET):
- 1) Performed by Contractor, ICSC, manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed.
    - a) The participants need to be dedicated full-time to CEET.
    - b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
    - c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
  - 2) Prerequisites:
    - a) CEET cannot begin until the successful completion of the preceding tests:
      - (1) Calibration.
      - (2) Loop check.
      - (3) Loop validation tests.
      - (4) LAN cable post-testing.
      - (5) Industrial network testing.
  - 3) Testing description:
    - a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
    - b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
    - c) SCADA screens:
      - (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
      - (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
      - (3) Retest any loop following any necessary corrections.
  - 4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system.
    - a) Use actual process inputs wherever available.
    - b) Issue commands from the HMI/SCADA system and verify proper responses of field devices.
      - (1) Test SCADA system inputs from field device to SCADA system operator workstations.
        - (a) Track responses through trend charts in the HMI/SCADA system.
      - (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.



- 2) Discrete device testing:
  - a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
    - (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
    - (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
    - (3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
  - b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
    - (1) Stroke valves through outputs from the HMI/SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
    - (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
    - (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
- 3) Analog device testing:
  - a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
  - b) Apply provisional settings on controllers and alarm setpoints.
- 4) Analog input:
  - a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system.
    - (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
- 5) Analog output:
  - a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system.
    - (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
    - (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.



- 6) Submit completed test forms.
  - a) Discrete instrument input devices:
    - (1) Switch setting, contact action, and dead band.
    - (2) Valve position switches:
      - (a) Response in the PLC as the valve is stroked from the PLC.
      - (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
    - (3) Operator interface switches (control stations and other pilot devices) and associated response.
    - (4) Starter and drive auxiliary device contact response.
    - (5) Response of all other discrete inputs to the PLC.
    - (6) Test equipment used and associated serial numbers.
  - b) Discrete output devices:
    - (1) Observed response of field device to the discrete output from the PLC.
    - (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
    - (3) Test equipment used and associated serial numbers.
  - c) Analog input devices:
    - (1) Calibration range.
    - (2) Calibration data: Input, output, and error at each test value.
    - (3) Analog input associated PLC register address.
    - (4) Value in PLC register at each test point.
    - (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
    - (6) Test equipment used and associated serial numbers.
  - d) Analog output devices:
    - (1) Calibration range.
    - (2) Test value at each test point.
    - (3) Analog output associated PLC register address.
    - (4) Control variable value at field device at each test point.
    - (5) Physical device response at each test point:
      - (a) Response to be actual valve position, or motor speed, etc.
    - (6) Test equipment used and associated serial numbers.
- 7) Failure testing:
  - a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
    - (1) Equipment failure.
    - (2) Communications sub-system error.
    - (3) Power failure.
    - (4) Process equipment failure.
    - (5) High system loading conditions.
- 8) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.



4. Functional testing:

a. General:

- 1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
- 2) Performed by Contractor, ICSC, manufacturer's representative together, with assistance from the OWNER or the inspection staff, as needed.
- 3) Additional tests are specified in other Instrumentation and Control Sections.
- 4) Follow approved detailed test procedures and check lists for Functional Test activities.

b. Control logic operational validation:

- 1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
- 2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
- 3) Test in detail on a function-by-function and sentence-by-sentence basis.
- 4) Thoroughly test hardware and software functions:
- 5) Including all hardwired and software control circuit interlocks and alarms.
- 6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
- 7) Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.

c. Loop tuning:

- 1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
- 2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
- 3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
- 4) Functional validation sheets:



- a) Document each Functional test on an approved test form.
  - b) Document loop tuning with a report for each loop, including two-open chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
  - c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
    - (1) Loop number and P&ID number.
    - (2) Control strategy, or reference to specification tested.
    - (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
  - d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
    - (1) Specification page and paragraph of function demonstrated.
    - (2) Description of function and/or text from specification.
    - (3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
  - 5) Functional certification:
    - a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
      - (1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.
- C. Process Start-up Phase:
- 1. Process Start-up:
    - a. ICSC shall be onsite to support Process Start-up activities and provide functional changes as required.
  - 2. Process Operation Period:
    - a. ICSC shall be available to support Process Operational Period and provide functional changes as required.
  - 3. PCIS Optimization and Fine-Tuning:
    - a. General:
      - 1) After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
      - 2) This is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
      - 3) The complete PLC control and HMI/SCADA system must run continuously for the duration of the PCIS Optimization and Fine-Tuning.
      - 4) Test and use the entire process control system under standard operating conditions.
      - 5) Exercise all system functions.





- 6) Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
  - a) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the PCIS Optimization and Fine-Tuning until final acceptance of the system.
    - (1) Response time to the Project Site: 24 hours or less, for a major failure.
  - b. SCADA system testing:
    - 1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
    - 2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
      - a) Corrective action is required before restarting the PCIS Optimization and Fine-Tuning.
    - 3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
    - 4) Failures:
      - a) Classify failures as either major or minor:
        - (1) Minor failure:
          - (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
          - (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
          - (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
          - (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
        - (2) Major failure:
          - (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
          - (b) Cause termination of the PCIS Optimization and Fine-Tuning.
          - (c) Start a new acceptance test when the causes of a major failure have been corrected.





- (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
- 5) Technician report:
  - a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
  - b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
  - c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
  - d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

### **3.07 FIELD QUALITY CONTROL (NOT USED)**

### **3.01 RE-INSTALLATION (NOT USED)**

### **3.02 ADJUSTING (NOT USED)**

### **3.03 CLEANING (NOT USED)**

### **3.04 PROTECTION (NOT USED)**

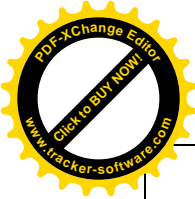
### **3.05 SCHEDULES**

- A. Example test forms:
  - 1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
  - 2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION



<b>FACTORY ACCEPTANCE TEST - CONTROL PANELS</b>											
<p><b>1. GENERAL INSPECTION</b></p> <p><b>A. Structural Inspection</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Verify Lifting Lugs Installed</li><li><input type="checkbox"/> Verify enclosure has lock and lock is functional</li><li><input type="checkbox"/> Confirm that seismic bracing components are provided per manufacturer's installation instructions</li></ul> <p><b>B. Exterior Inspection</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Cabinet exterior is clean, scratch, and dent free</li><li><input type="checkbox"/> Inspect externally for corrosion and damage</li><li><input type="checkbox"/> Verify enclosure door opens and closes easily</li><li><input type="checkbox"/> Verify enclosure has a 3-point latch</li><li><input type="checkbox"/> Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)</li><li><input type="checkbox"/> Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.)</li><li><input type="checkbox"/> Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)</li></ul> <p><b>Nameplates</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Cabinet has identification nameplate</li><li><input type="checkbox"/> All door labels are straight, spelled correctly, and match the tagging defined in the Contract</li><li><input type="checkbox"/> Cabinet has a nameplate that includes the following:<ul style="list-style-type: none"><li><input type="checkbox"/> Power source(s)                      <input type="checkbox"/> Integrator's Logo</li><li><input type="checkbox"/> Circuit ID(s)                              <input type="checkbox"/> Short Circuit KAIC ratings</li></ul></li><li><input type="checkbox"/> If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)</li></ul> <p><b>Door Devices</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> All devices penetrating the outside of panel have gaskets, silicone or both</li><li><input type="checkbox"/> All door devices are installed (HMIs, Pilot Devices, etc.)</li><li><input type="checkbox"/> Door mounted equipment is mounted straight and square</li><li><input type="checkbox"/> All exterior or door mounted equipment present and accounted for, installed and securely fastened</li><li><input type="checkbox"/> NEMA classification has not been violated due to penetrations</li><li><input type="checkbox"/> Door mounted equipment has the same NEMA rating as the panel</li><li><input type="checkbox"/> All door mounted equipment installed at the correct height</li><li><input type="checkbox"/> All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)</li><li><input type="checkbox"/> Doors with multiple penetrations have adequate bracing (if needed)</li><li><input type="checkbox"/> Visually check condition of indicators , controllers and annunciators</li><li><input type="checkbox"/> Check that pilot lights illuminate correctly</li><li><input type="checkbox"/> Check the Push-To-Test function</li><li><input type="checkbox"/> Ensure correct pilot light color</li></ul> <p><b>Peripheral Devices</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Horn / Beacon is installed (where required)</li><li><input type="checkbox"/> Silence and Reset pushbutton</li></ul>											
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FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>1. GENERAL INSPECTION (continued)</b></p> <p><b>C. Interior Inspection</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Cabinet is cleaned of marks and dirt.</li><li><input type="checkbox"/> Inspect internally for corrosion and damage.</li><li><input type="checkbox"/> Back panel is clean of marks and dirt.</li><li><input type="checkbox"/> Interior of panel vacuumed and shall be free of all debris.</li><li><input type="checkbox"/> Check that the panel roof is clean and clear of foreign materials.</li><li><input type="checkbox"/> Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.</li><li><input type="checkbox"/> If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.</li><li><input type="checkbox"/> Check that a document pocket has been provided.</li><li><input type="checkbox"/> Intrusion alarms (where required).</li></ul> <p><b>Interior Labeling</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.</li><li><input type="checkbox"/> Verify that door mounted components are mounted square and symmetrical.</li><li><input type="checkbox"/> Verify that nameplates are straight, legible, and spelled correctly.</li><li><input type="checkbox"/> All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.</li><li><input type="checkbox"/> All wiring shrink labeled and or phased correctly to the specifications.</li><li><input type="checkbox"/> All wire labels shrunk completely rotated and aligned alike for easy identification.</li><li><input type="checkbox"/> All fuses and circuit breakers are labeled with ID and current rating.</li><li><input type="checkbox"/> System Integrator's label or labels installed on door.</li><li><input type="checkbox"/> Panel manufacturer model/serial number tag is present.</li><li><input type="checkbox"/> All required safety/warning tags installed and straight.</li><li><input type="checkbox"/> Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).</li></ul> <p><b>Wireways</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Plastic wire way covers installed properly.</li><li><input type="checkbox"/> Plastic wireways have no sharp edges.</li><li><input type="checkbox"/> No wire Ties inside the wireways.</li><li><input type="checkbox"/> No sharp edges on wire ties.</li><li><input type="checkbox"/> Separation: White duct is used for DC voltages, Gray duct is used for AC voltages.</li><li><input type="checkbox"/> Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.</li></ul>											
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FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>1. GENERAL INSPECTION (continued)</b></p> <p><b>C. Interior Inspection (continued)</b></p> <p><b>Wiring</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Visually check terminals and condition of internal wirings</li><li><input type="checkbox"/> Verify that the control panel has been assembled and wired as designed</li><li><input type="checkbox"/> Verify that all components are operational and perform the functions intended</li><li><input type="checkbox"/> Verify that all components are sized appropriately for the application</li><li><input type="checkbox"/> Verify that equipment control circuits function as intended</li><li><input type="checkbox"/> Back of door wiring is labeled and neatly formed</li><li><input type="checkbox"/> Back panel to door wiring has sufficient bending radius with spiral wrap</li><li><input type="checkbox"/> Wire connection has been verified wired to correct points within the panel</li><li><input type="checkbox"/> Individual wires have been given a pull test to verify a good terminal connection</li><li><input type="checkbox"/> Wire and cable minimum bending radius have not been violated</li><li><input type="checkbox"/> All equipment installed straight and square to back panel</li><li><input type="checkbox"/> Wire colors are correct:<ul style="list-style-type: none"><li><input type="checkbox"/> Black and White &gt; AC hot and neutral, respectively</li><li><input type="checkbox"/> Red &gt; AC control signals</li><li><input type="checkbox"/> Blue &gt; DC power and control (Blue w/White stripe for DC ground)</li><li><input type="checkbox"/> Yellow &gt; Foreign voltages (those still present when panel power is disconnected)</li><li><input type="checkbox"/> Green &gt; AC equipment ground</li><li><input type="checkbox"/> Black &gt; TSP (+)</li><li><input type="checkbox"/> White&gt; TSP(-)</li></ul></li><li><input type="checkbox"/> Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)</li><li><input type="checkbox"/> Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself</li><li><input type="checkbox"/> Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis</li><li><input type="checkbox"/> Intrinsic Safety Wiring<ul style="list-style-type: none"><li><input type="checkbox"/> Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring</li></ul></li><li><input type="checkbox"/> Verify all spare terminals are installed according to the percentage listed in the specifications</li></ul> <p><b>Grounding</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Equipped with "Blackburn" or other grounding type lug</li><li><input type="checkbox"/> Lug is securely fastened to the panel structure</li><li><input type="checkbox"/> Verify Grounding bar is installed</li><li><input type="checkbox"/> Verify Isolated ground bar is installed</li></ul>											
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FACTORY ACCEPTANCE TEST - CONTROL PANELS	
<b>2. POWER TEST</b>	
<b>A. AC Power</b>	
<input type="checkbox"/> AC Power is routed correctly within the panel, and is isolated from DC and network wiring.	
<input type="checkbox"/> All fuses are installed and sized properly.	
<input type="checkbox"/> All breakers are installed and sized properly.	
<input type="checkbox"/> 24 VDC Power Supplies are functional.	
<input type="checkbox"/> 24 VDC Power fail contacts are functional.	
<input type="checkbox"/> 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies. <input type="checkbox"/> 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.	
<input type="checkbox"/> Dedicated receptacle is wired to receive a dedicated AC supply.	
<input type="checkbox"/> Verify continuity for all DC commons, ground and AC neutrals.	
<input type="checkbox"/> Verify that the CP temporary input power is connected correctly and is the correct voltage.	
<input type="checkbox"/> Close the CP main circuit breaker(s).	
<input type="checkbox"/> Verify that voltages at subsequent circuit breakers are correct.	
<input type="checkbox"/> Close circuit breakers.	
<input type="checkbox"/> Verify that power feeding interruptible and uninterruptible power supplies is correct.	
<input type="checkbox"/> Turn on power supplies if they are not already on.	
<input type="checkbox"/> Verify that voltages at distribution terminals are correct.	
<input type="checkbox"/> Energize any remaining hardware such as the PLC.	
<b>B. Uninterruptible Power Supply (UPS)</b>	
<input type="checkbox"/> Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.	
<input type="checkbox"/> Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).	
<input type="checkbox"/> Test all UPS alarms (on inverter, failure, battery failure etc.)	
<input type="checkbox"/> Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.	
<b>3. CONTROLS &amp; AUXILIARY DEVICES TEST</b>	
<input type="checkbox"/> Verify all interposing and auxiliary relays are functioning.	
<input type="checkbox"/> Verify panel lights are functioning.	
<b>Ventilation and Heating</b>	
<input type="checkbox"/> If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.	
<input type="checkbox"/> Verify components are installed in the correct orientation for proper air flow.	
<b>4. HARDWIRED INTERLOCK AND SAFETY TEST</b>	
<input type="checkbox"/> Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.	
<input type="checkbox"/> Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.	
PROJECT NAME: _____ TEST DATE: _____	
FACILITY NAME: _____ TESTED BY: _____	
PROCESS AREA: _____ COMPANY: _____	
NETWORK ID: _____ PAGE: _____	
WITNESSED BY: _____ SIGNATURE: _____	



<b>FACTORY ACCEPTANCE TEST - CONTROL PANELS</b>											
<p><b>5. PLC TEST</b></p> <p><b>A. Components</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.</li><li><input type="checkbox"/> Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.</li><li><input type="checkbox"/> TVSS is installed across the main incoming 120 VAC.</li></ul> <p><b>PLC and PLC Rack</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Verify all cards are securely seated.</li><li><input type="checkbox"/> Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations.</li></ul> <p><b>B. PLC I/O Test</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Furnish <b>I/O test forms</b> and test all the listed input and output points as follows:<ul style="list-style-type: none"><li><input type="checkbox"/> Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software.</li><li><input type="checkbox"/> Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting.</li><li><input type="checkbox"/> Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.</li><li><input type="checkbox"/> Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.</li></ul></li></ul> <p><b>C. Redundant Controllers (where required) Test</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Remove Communication cable from primary PLC to verify switching to backup PLC</li><li><input type="checkbox"/> Remove Communication cable from backup PLC to verify switching back to primary PLC</li><li><input type="checkbox"/> Remove Power cable from primary PLC to verify switching to backup PLC</li><li><input type="checkbox"/> Remove Power cable from backup PLC to verify switching back to primary PLC</li></ul> <p><b>D. PLC Control Logic Verification</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.<ul style="list-style-type: none"><li><input type="checkbox"/></li><li><input type="checkbox"/> DI states are either simulated by hardwired switches or forced inputs using a programming terminal.</li><li><input type="checkbox"/> For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.</li></ul></li></ul>											
<table style="width: 100%; border: none;"><tr><td style="width: 50%; border: none;">PROJECT NAME: _____</td><td style="width: 50%; border: none;">TEST DATE: _____</td></tr><tr><td style="border: none;">FACILITY NAME: _____</td><td style="border: none;">TESTED BY: _____</td></tr><tr><td style="border: none;">PROCESS AREA: _____</td><td style="border: none;">COMPANY: _____</td></tr><tr><td style="border: none;">NETWORK ID: _____</td><td style="border: none;">PAGE: _____</td></tr><tr><td style="border: none;">WITNESSED BY: _____</td><td style="border: none;">SIGNATURE: _____</td></tr></table>		PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____										
FACILITY NAME: _____	TESTED BY: _____										
PROCESS AREA: _____	COMPANY: _____										
NETWORK ID: _____	PAGE: _____										
WITNESSED BY: _____	SIGNATURE: _____										

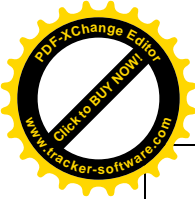


FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>5. PLC TEST (continued)</b></p> <p><b>D. PLC Control Logic Verification (continued)</b></p> <p><b>Typical Fault Logic</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.</li><li><input type="checkbox"/> The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.</li></ul> <p><b>Typical Fail to Start Logic</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.</li></ul>											
<p><b>6. HMI OR OIT TEST</b></p> <p><b>HMI / OIT Functionality</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Communication with PLC</li><li><input type="checkbox"/> Screen Layouts</li><li><input type="checkbox"/> Screen Navigation</li><li><input type="checkbox"/> Set Point Entry</li><li><input type="checkbox"/> Animation</li><li><input type="checkbox"/> Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)</li><li><input type="checkbox"/> Alarms</li><li><input type="checkbox"/> Acknowledge and Reset</li><li><input type="checkbox"/> Security / Access Levels / Passwords</li></ul>											
<p><b>7. NETWORK COMMUNICATION TEST</b></p> <p><b>A. Network Components</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Fiber optic cabling terminates in a patch panel</li><li><input type="checkbox"/> Media converters are installed and functional</li><li><input type="checkbox"/> Terminating resistors have been installed for trunk/tap topologies or where required</li><li><input type="checkbox"/> Wire and cable bending limitations have not been violated</li></ul> <p><b>B. Networking Functions</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams</li><li><input type="checkbox"/> Verify network traffic rate and error margin is acceptable</li></ul>											
<table border="0"><tr><td>PROJECT NAME: _____</td><td>TEST DATE: _____</td></tr><tr><td>FACILITY NAME: _____</td><td>TESTED BY: _____</td></tr><tr><td>PROCESS AREA: _____</td><td>COMPANY: _____</td></tr><tr><td>NETWORK ID: _____</td><td>PAGE: _____</td></tr><tr><td>WITNESSED BY: _____</td><td>SIGNATURE: _____</td></tr></table>		PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____										
FACILITY NAME: _____	TESTED BY: _____										
PROCESS AREA: _____	COMPANY: _____										
NETWORK ID: _____	PAGE: _____										
WITNESSED BY: _____	SIGNATURE: _____										



FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<b>8. FAT DOCUMENTATION AND RECORD</b> <b>Panel Documentation</b> <ul style="list-style-type: none"><li><input type="checkbox"/> As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.</li><li><input type="checkbox"/> Panel schematic and interconnection drawings.</li><li><input type="checkbox"/> P&amp;ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.</li><li><input type="checkbox"/> I/O list test forms of the process area to be tested.</li><li><input type="checkbox"/> FAT procedure of the process area to be tested.</li><li><input type="checkbox"/> Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.</li><li><input type="checkbox"/> Hard copy of the PLC application program of the process area to be tested.</li><li><input type="checkbox"/> Hard copy of the HMI/OIT graphic screens of the process area to be tested.</li></ul>											
<b>9. FAT TOOLS AND SOFTWARE</b> <ul style="list-style-type: none"><li><input type="checkbox"/> Simulation software if required</li><li><input type="checkbox"/> Digital volt meter Fluke 87</li><li><input type="checkbox"/> Process meter Fluke 787</li><li><input type="checkbox"/> Laptop computer with PLC application program</li><li><input type="checkbox"/> Temporary SCADA computer with HMI software and applicable graphic screens</li><li><input type="checkbox"/> Jumper wires</li></ul>											
<table><tr><td>PROJECT NAME: _____</td><td>TEST DATE: _____</td></tr><tr><td>FACILITY NAME: _____</td><td>TESTED BY: _____</td></tr><tr><td>PROCESS AREA: _____</td><td>COMPANY: _____</td></tr><tr><td>NETWORK ID: _____</td><td>PAGE: _____</td></tr><tr><td>WITNESSED BY: _____</td><td>SIGNATURE: _____</td></tr></table>		PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____										
FACILITY NAME: _____	TESTED BY: _____										
PROCESS AREA: _____	COMPANY: _____										
NETWORK ID: _____	PAGE: _____										
WITNESSED BY: _____	SIGNATURE: _____										





	<b>INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION</b>	
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INSTRUMENT LOOP NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

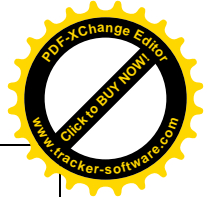
REMARKS: \_\_\_\_\_

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CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
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SIGNATURE _____	SIGNATURE _____
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DATE _____	DATE _____
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	<b>SWITCHES INSTALLATION AND CALIBRATION CHECKLIST</b>	
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INSTRUMENT LOOP NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ VERIFIED PER P&ID NO. \_\_\_\_\_
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_
- ☐ INSTALLATION CORRECT PER DETAIL NO. \_\_\_\_\_
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

FIELD CALIBRATION CHECK						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS	
1	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
2	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
3	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
4	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE



	<p style="text-align: center;"><b>SWITCHES</b> <b>INSTALLATION AND CALIBRATION CHECKLIST</b></p>	
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CHECKED BY (COMPANY) \_\_\_\_\_

SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_



	<b>TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST</b>	
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INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

☐ No ☐ Yes

INSTRUMENT TYPE  
INDICATOR

☐ TRANSMITTER ☐ CONTROLLER ☐  
☐ OTHER

DESCRIPTION \_\_\_\_\_

INSTRUMENT TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

SERVICE  
DESCRIPTION \_\_\_\_\_

**BENCH CALIBRATION CHECK**

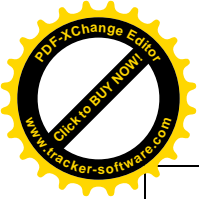
INPUT RANGE = _____		OUTPUT RANGE = _____		
HEAD CORRECTION = _____		<input type="checkbox"/> LINEAR		
CALIBRATED SPAN = _____		<input type="checkbox"/> SQUARE ROOT		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ VERIFIED PER P&ID NO. \_\_\_\_\_
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_
- ☐ INSTALLATION CORRECT PER DETAIL NO. \_\_\_\_\_
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

**FIELD CALIBRATION CHECK**

INPUT RANGE = _____		OUTPUT RANGE = _____		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				



	<b>TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST</b>	
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- ☐ DIRECT                      ☐ REVERSE
- ☐ ACTION VERIFIED AT 50% SPAN
- ☐ ACTION VERIFIED AT \_\_\_\_\_ SPAN

CONTROLLER SETTINGS								
SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS \_\_\_\_\_

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CHECKED BY (COMPANY) \_\_\_\_\_ ACCEPTED BY  
(COMPANY) \_\_\_\_\_

SIGNATURE \_\_\_\_\_ SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_ DATE \_\_\_\_\_



	<b>ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST</b>	
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INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

TYPE OF INSTRUMENT \_\_\_\_\_

INSTRUMENT TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

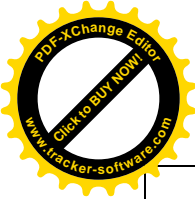
SERVICE DESCRIPTION \_\_\_\_\_

CHECK BELOW, IF TRUE

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ VERIFIED PER P&ID NO. \_\_\_\_\_
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_
- ☐ INSTALLATION CORRECT PER DETAIL NO. \_\_\_\_\_
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS \_\_\_\_\_  
\_\_\_\_\_  
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CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____



	<b>CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST</b>	
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☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

☐ VALVE TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ TRANSDUCER TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ SOLENOID TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ VOLUME BOOSTER TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ POSITIONER \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE \_\_\_\_\_

☐ VERIFIED PER P&ID NO. \_\_\_\_\_

☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_

☐ VALVE SPECIFICATION NO. \_\_\_\_\_

☐ TRANSDUCER SPECIFICATION NO. \_\_\_\_\_

☐ SOLENOID SPECIFICATION NO. \_\_\_\_\_

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS \_\_\_\_\_

☐ VALVE DETAIL NO. \_\_\_\_\_

☐ TRANSDUCER DETAIL NO. \_\_\_\_\_

☐ SOLENOID DETAIL NO. \_\_\_\_\_



	<b>CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST</b>	
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- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	<input type="checkbox"/> PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS		ON LOSS OF POWER SOLENOID FAILS
	<input type="checkbox"/> OPEN <input type="checkbox"/> CLOSE	<input type="checkbox"/> TO VENT <input type="checkbox"/> TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
	<input type="checkbox"/> ON BENCH <input type="checkbox"/> IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS \_\_\_\_\_

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CHECKED BY (COMPANY) \_\_\_\_\_ ACCEPTED BY (COMPANY) \_\_\_\_\_

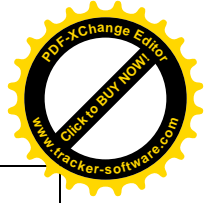
SIGNATURE \_\_\_\_\_ SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_ DATE \_\_\_\_\_





DEVICENET INSTALLATION TESTING		
DeviceNet Network _____		
<b>Network Installation Characteristics</b>		
<u>Architecture</u>	<u>Baud Rate</u>	<u>Trunk Media</u>
<input type="checkbox"/> Single Master or <input type="checkbox"/> Multi Master <input type="checkbox"/> Redundant Power Supplies <input type="checkbox"/> Per Network	<input type="checkbox"/> 125 kBaud <input type="checkbox"/> 250 kBaud <input type="checkbox"/> 500 kBaud	<u>Drop Media</u> <input type="checkbox"/> Thick Round, Unshielded <input type="checkbox"/> Thin Round, Shielded <input type="checkbox"/> Thick Round, Shielded
<u>Installed Node List</u>		
<input type="checkbox"/> 0 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> 8 <input type="checkbox"/> 9 <input type="checkbox"/> 10 <input type="checkbox"/> 11 <input type="checkbox"/> 12 <input type="checkbox"/> 13 <input type="checkbox"/> 14 <input type="checkbox"/> 15 <input type="checkbox"/> 16 <input type="checkbox"/> 17 <input type="checkbox"/> 18 <input type="checkbox"/> 19 <input type="checkbox"/> 20 <input type="checkbox"/> 21 <input type="checkbox"/> 22 <input type="checkbox"/> 23 <input type="checkbox"/> 24 <input type="checkbox"/> 25 <input type="checkbox"/> 26 <input type="checkbox"/> 27 <input type="checkbox"/> 28 <input type="checkbox"/> 29 <input type="checkbox"/> 30 <input type="checkbox"/> 31 <input type="checkbox"/> 32 <input type="checkbox"/> 33 <input type="checkbox"/> 34 <input type="checkbox"/> 35 <input type="checkbox"/> 36 <input type="checkbox"/> 37 <input type="checkbox"/> 38 <input type="checkbox"/> 39 <input type="checkbox"/> 40 <input type="checkbox"/> 41 <input type="checkbox"/> 42 <input type="checkbox"/> 43 <input type="checkbox"/> 44 <input type="checkbox"/> 45 <input type="checkbox"/> 46 <input type="checkbox"/> 47 <input type="checkbox"/> 48 <input type="checkbox"/> 49 <input type="checkbox"/> 50 <input type="checkbox"/> 51 <input type="checkbox"/> 52 <input type="checkbox"/> 53 <input type="checkbox"/> 54 <input type="checkbox"/> 55 <input type="checkbox"/> 56 <input type="checkbox"/> 57 <input type="checkbox"/> 58 <input type="checkbox"/> 59 <input type="checkbox"/> 60 <input type="checkbox"/> 61 <input type="checkbox"/> 62 <input type="checkbox"/> 63		
<input type="checkbox"/> All nodes present and in accordance with network drawings/specifications <span style="float: right;"><input type="checkbox"/> ODVA approved devices</span>		
<input type="checkbox"/> Nodes/devices accessible for inspection and maintenance <span style="float: right;"><input type="checkbox"/> Nodes/devices properly addressed</span>		
Comments: _____ _____ _____		
<b>Media Inspection</b>		
<u>Trunk Cable</u>	<u>Drop Cable</u>	<u>Installation</u>
<input type="checkbox"/> ODVA approved <input type="checkbox"/> Labeling complete <input type="checkbox"/> Cable/conductor terminations <input type="checkbox"/> Terminating resistors at ends	<input type="checkbox"/> ODVA approved <input type="checkbox"/> Labeling complete <input type="checkbox"/> Cable/conductor terminations <input type="checkbox"/> Maximum drop length < 20'	<input type="checkbox"/> No evidence of physical damage <input type="checkbox"/> Installed in protective raceway <input type="checkbox"/> Bending radius not exceeded  <input type="checkbox"/> Cable supports in place  <input type="checkbox"/> V- and shield are grounded <input type="checkbox"/> Clearance from high temperature/voltage sources <input type="checkbox"/> No installation subject to vibration
Comments: _____ _____ _____		



### Network Power Supplies

#### Power Supply Equipment

- ☐ ODVA compliant
- ☐ Quantity and ratings

#### Supply Source (120 VAC)

- ☐ Overcurrent protection
- ☐ Conductor size

#### Network Power Tap (24 VDC)

- ☐ Overcurrent protection
- ☐ Conductor size

Comments:

---

---

---

CHECKED BY (COMPANY)

ACCEPTED BY  
(COMPANY)

SIGNATURE

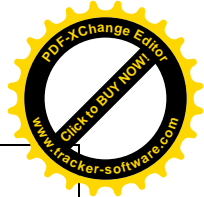
SIGNATURE

DATE

DATE



7190700 FCWRF Industrial EQ Basin Rehab 17950-34  
Little Rock Water Reclamation Authority



**PROFIBUS  
INSTALLATION QUALIFICATION AND TESTING**

**Media Inspection**

<b>CABLING</b>	<b>DP NETWORK</b>	<b>PA NETWORK SEGMENTS</b>				
PI COMPLIANT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
LABELING COMPLETE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
GROUNDING	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
CABLE AND CONDUCTOR TERMINATIONS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
NO STUB LINES (DP ONLY)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
TERMINATING RESISTORS (IN PLACE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
DEDICATED DIAGNOSTICS BUS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
INSTALLATION						
NO EVIDENCE OF PHYSICAL DAMAGE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
INSTALLATION IN PROTECTIVE RACEWAY	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
CLEARANCES FROM HIGH TEMPERATURE SOURCES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
CLEARANCES FROM HIGH VOLTAGE SOURCES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
BEND RADIUS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
NO INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)						

**Device Inspection**

<b>DEVICE QUANTITY/TYPE</b>	<b>INSTALLATION</b>
<input type="checkbox"/> TOTAL SLAVE COUNT	<input type="checkbox"/> NO EVIDENCE OF PHYSICAL DAMAGE
<input type="checkbox"/> MOST UPDATED DEVICE DRIVER INSTALLED?	<input type="checkbox"/> ACCESSIBLE FOR INSPECTION AND MAINTENANCE
<input type="checkbox"/> INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS	<input type="checkbox"/> FDT COMPLIANT DEVICES
<input type="checkbox"/> PI COMPLIANCE DEVICES	
<input type="checkbox"/> DIAGNOSTICS MODULE INSTALLED	
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)	

**Power Supplies**

<b>ACTIVE TERMINATIONS</b>	<b>COUPLERS</b>	<b>REPEATERS</b>
<input type="checkbox"/> SOURCE LOCATION	<input type="checkbox"/> SOURCE LOCATION	<input type="checkbox"/> SOURCE LOCATION
<input type="checkbox"/> OVERCURRENT PROTECTION	<input type="checkbox"/> OVERCURRENT PROTECTION	<input type="checkbox"/> OVERCURRENT PROTECTION
<input type="checkbox"/> CONDUCTOR SIZE	<input type="checkbox"/> CONDUCTOR SIZE	<input type="checkbox"/> CONDUCTOR SIZE
<input type="checkbox"/> GROUNDING	<input type="checkbox"/> GROUNDING	<input type="checkbox"/> GROUNDING
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)		

PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____	SIGNATURE: _____



PROFIBUS  
INSTALLATION QUALIFICATION AND TESTING

DP Network Media Testing

DESCRIPTION	SEGMENT ID																								
<b>TRUNK LENGTH (feet)</b>																									
ALLOWABLE TRUNK LENGTH AT SPECIFIED DATA RATE:																									
MEASURED TRUNK LENGTH:																									
SPARE TRUNK LENGTH																									
<b>RESISTANCE MEASUREMENTS (ohms)</b>																									
NETWORK CABLE:																									
NO TERMINATIONS																									
ONE TERMINATION																									
TWO TERMINATIONS																									
<b>POWER SUPPLY VOLTAGE (volts DC)</b>																									
ACTIVE TERMINATOR																									
REPEATER CP1100-RPT1																									
REPEATER CP1000-RPT1																									
REPEATER CP1000-RPT2																									
REPEATER CP2700-RPT1																									
<b>CABLE TEXTS</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>													
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES AND SHIELD	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
TESTED FOR SHIELD CONTINUITY	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
TESTED FOR OPEN SIGNAL LINES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
TESTED FOR CROSSED SIGNAL LINES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
TESTED FOR CORRECT TERMINATOR POSITION	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
CORRECT CABLE TYPE AND LENGTH	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
TESTED FOR SECURE AND TIGHT CONNECTORS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>													
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)																									
<table><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																									

PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____	SIGNATURE: _____

Permit Numbers and/or names of any permits issued by ADEQ or EPA for an activity located in Arkansas that is presently held by the applicant or its parent or subsidiary corporation which are not listed above:

<b>Permit Name</b>	<b>Permit Number</b>	<b>Held By</b>
Air Permit	2095-AR-1	LRWRA
NPDES Permit – Little Maumelle	AR0050849	LRWRA
Storm Water Permit – Little Maumelle	ARR000873	LRWRA
Storage Tank Permit – Little Maumelle	60002130	LRWRA
NPDES Permit – Adams Field	AR0021806	LRWRA
Storm Water Permit – Adams Field	ARR00A001	LRWRA
Storage Tank Permit – Adams Field	60000291	LRWRA
Construction Permit – Adams Field	AR002180GC	LRWRA
NPDES Permit – Fourche Creek	AR0040177	LRWRA
Storm Water Permit – Fourche Creek	ARR001276	LRWRA
Storage Tank Permit – Fourche Creek	60000289	LRWRA
Hazardous Waste Permit – Fourche Creek	AR0000000109	LRWRA
Construction Permit – Fourche Creek	AR0040177C	LRWRA
Hazardous Waste Permit – Clearwater Maintenance	ARD983276304	LRWRA
Storage Tank Permit – Clearwater Maintenance	60001067	LRWRA
Storm Water Permit – Peak Flow	ARR155052	LRWRA
Storage Tank Permit – Peak Flow	6002122	LRWRA
Storage Tank Permit – Arch Street	60002136	LRWRA
Storage Tank Permit – Little Maumelle Pump Station	60002123	LRWRA

## PROCESS DESCRIPTION

Normal Operating Conditions: screening, grit removal, primary clarification, activated sludge, polymer injection (as needed), secondary clarification, chlorine disinfection, sulfur dioxide dichlorination, and equalization/treatment of high strength wastewater in sludge digesters (co-digestion).

Peak Flow Conditions: 36 MGD is treated using the same processes as in Normal Operating Conditions. Flow in excess of 36 MGD are treated by: screening, activated sludge, polymer injection (as needed), secondary clarification, chlorine disinfection, sulfur dioxide dichlorination, and equalization/treatment of high strength wastewater in sludge digesters (co-digestion).

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# State Construction Permit Application for Wastewater Treatment Facilities

version 1.11

(Submission #: HP4-WFBN-TJ0P7, version 1)

## Details

---

<b>Form Alias</b>	State Construction Permit Application for Wastewater Treatment Facilities		
<b>Form Started</b>	12/9/2020 1:45 PM by Jamie L Ewing		
<b>Form Submitted</b>	12/21/2020 1:53 PM by Gregorio Ramon		
<b>Submission #</b>	HP4-WFBN-TJ0P7		
<b>Submission Reason</b>	New		
<b>Status</b>	Submitted		
<b>Active Steps</b>	Application Processing - AA		
<b>AFIN:</b>	60-01021	<b>Reference #</b>	AR0040177C2
<b>Description</b>	AR0040177C2 - LRWRA - Fourche Creek - Construction		
<b>Fee</b>	\$500.00 (Due)		

## Form Input

---

### Common Information

#### Facility Information

---

Please provide the following information about the Facility.

#### **ADEQ Facility Identification Number (AFIN)**

60-01021

#### **Facility Name**

Fourche Creek Water Reclamation Facility

#### **North American Industry Classification System (NAICS)**

Please provide the NAICS codes and descriptions for your facility.

[Click here to search for and review the NAICS Codes via the Census Bureau NAICS Lookup](#)

#### **Primary NAICS Code and Description**

221320 - Sewage Treatment Facilities

#### **Secondary NAICS Code and Description**

NONE PROVIDED

#### **Tertiary NAICS Code and Description**

NONE PROVIDED

**Facility Physical Address****Contact****Prefix**

NONE PROVIDED

**First Name**

Eric

**Last Name**

Wassell

**Title**

Water Reclamation Facility Senior Manager

**Organization Name**

Little Rock Water Reclamation Authority

**Phone Type****Number****Extension**

Business

501-490-5402

**Email**

eric.wassell@lrwa.com

**Fax**

NONE PROVIDED

**Physical Address**

9500 BIRDWOOD DR

LITTLE ROCK, AR 72206

Pulaski, United States

**Facility Physical Location Latitude and Longitude**

34.699222,-92.168167

NONE PROVIDED

**Facility Mailing Address****Contact****Prefix**

NONE PROVIDED

**First Name**

Walter

**Last Name**

Collins

**Title**

Director of Operations and Facilities

**Organization Name**

Little Rock Water Reclamation Authority

**Phone Type****Number****Extension**

Business

501-688-1429

**Email**

walter.collins@lrwa.com

**Fax**

NONE PROVIDED

**Mailing Address**

11 CLEARWATER DR

LITTLE ROCK, AR 72204

United States

**Owner Information**

---

Please provide the following information for the owner. If the owner is a corporation it must exactly match the name registered with the Secretary of State. Please use the following link to reference the Secretary of State registered name listing.

[Click here to view the Secretary of State registered name listing](#)

**Secretary of State's Filing Number**

AR

**Legal Organization**

Local Government (includes city, county, PID, SWD, SID and school district)

**Owner Type**

Local Government

NOTE: The Facility Mailing Address will be used for the Owner Information unless another address is provided below.

**Owner Information****Contact****Prefix**

NONE PROVIDED

**First Name**

Gregorio

**Last Name**

Ramon

**Title**

Chief Executive Officer

**Organization Name**

Little Rock Water Reclamation Authority

**Phone Type****Number****Extension**

Business

501-688-1404

**Email**

greg.ramon@lrwa.com

**Fax**

NONE PROVIDED

**Owner Address**

11 CLEARWATER DR

LITTLE ROCK, Arkansas 72204

United States

**Billing Information**

---

Please provide the following information for the Billing contact for this permit application.

NOTE: The Facility Mailing Address will be used for the Billing Information unless another address is provided below.

**Billing Information****Billing Contact****Prefix**

NONE PROVIDED

**First Name**

Gregorio

**Last Name**

Ramon

**Title**

Chief Executive Officer

**Organization Name**

Little Rock Water Reclamation Authority

**Phone Type****Number****Extension**

Business

501-688-1404

**Email**

greg.ramon@lrwa.com

**Fax**

NONE PROVIDED

**Billing Address**

11 CLEARWATER DR

LITTLE ROCK, AR 72204

United States

## Section A - General Information

---

**NPDES Individual Permit Number**

AR0040177

**NPDES General Permit Number**

NONE PROVIDED

**NPDES General Stormwater Permit Number**

ARR001276

**No-Discharge Permit Number**

NONE PROVIDED

**Permit Numbers and/or names of any permits issued by ADEQ or EPA for an activity located in Arkansas that is presently held by the applicant or its parent or subsidiary corporation which are not listed above**

See attached list, included with technical information in Section H.

**Neighboring States within 20 miles of the permitted facility**

NONE PROVIDED

**Design Flow**

16

**Highest Monthly Average of the last two years Flow**

16.97

**Is Outfall equipped with a diffuser?**

No

**Responsible Official**

---

The information contained in this form must be certified by a responsible official as defined in the "signatory requirements for permit applications" (40 CFR 122.22).

Note: The electronic application must be submitted by the responsible official. In addition, before the application can be submitted the responsible official will need to submit a one-time Electronic Signature Agreement Form. Once the Electronic Signature Agreement Form is submitted, ADEQ will review and validate the information before approving the agreement, at which point ADEQ will modify the user's privileges to allow the user to submit electronic documents that normally require a hardcopy signature.

Responsible official is defined as follows:

Corporation, a principal officer of at least the level of vice president

Partnership, a general partner

Sole proprietorship: the proprietor

Municipal, state, federal, or other public facility: principal executive officer, or ranking elected official.

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment for knowing violations. I further certify under penalty of law that all analyses reported as less than detectable in this application or attachments thereto were performed using the EPA approved test method having the lowest detection limit for the substance tested."

**Responsible Official****Contact Information****Prefix***NONE PROVIDED***First Name***Gregorio***Last Name***Ramon***Title***Chief Executive Officer***Organization Name***Little Rock Water Reclamation Authority***Phone Type***Business***Number***501-688-1401***Extension****Email***greg.ramon@lrwra.com***Fax***NONE PROVIDED***Address***11 CLEARWATER DR**LITTLE ROCK, AR 72204**AR, [NO COUNTRY SPECIFIED]***Is emailing all documents acceptable to the applicant?***No***Cognizant Official (Duly Authorized Representative)**

---

"By submission of this application with electronic signature by the responsible official, certify that the named individual listed below to act as a duly authorized representative under the provisions of 40 CFR 122.22(b).

Note: If no duly authorized representative is designated in this section, the Department considers the applicant to be the responsible official for the facility and only reports, etc., signed by the applicant will be accepted by the Department.

**Cognizant Official (Duly Authorized Representative)**

40 CFR 122.22(b) states that all reports required by the permit, or other information requested by the Director, shall be signed by the applicant (or person authorized by the applicant) or by a duly authorized representative of that person. A person is duly authorized representative only if:

- (1) the authorization is made in writing by the applicant (or person authorized by the applicant);
- (2) the authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity responsibility, or an individual or position having overall responsibility for environmental matters for the company.

The applicant hereby designates the following person as a Cognizant Official, or duly authorized representative, for signing reports, etc., including Discharge Monitoring Reports (DMR) required by the permit, and other information requested by the Director:

**Cognizant Official****Contact Information****Prefix***NONE PROVIDED***First Name**

Walter

**Last Name***Collins***Title***Director of Operations and Facilities***Organization Name***Little Rock Water Reclamation Authority***Phone Type**

Business

**Number**

501-688-1429

**Extension****Email**

walter.collins@lrwra.com

**Fax***NONE PROVIDED***Address**

11 CLEARWATER DR

LITTLE ROCK, Arkansas 72204

United States

**Consulting Engineer Firm**

---

**Active Consulting Engineer Firm****Contact Information****Prefix***NONE PROVIDED***First Name**

John

**Last Name***Holloway***Title***Director of Engineering***Organization Name***Little Rock Water Reclamation Authority***Phone Type**

Business

**Number**

5016881416

**Extension****Email**

john.holloway@lrwra.com

**Fax***NONE PROVIDED***Address**

11 CLEARWATER DR

LITTLE ROCK, AR 72204

[NO COUNTY SPECIFIED], United States

**Wastewater Operator Name****Name**

Eric L. Wassell

**Title**

Water Reclamation Facility Senior Manager

**Operator License Number**

003691

**Class of Municipal Wastewater Operator**

IV

## **Section B1 - Outfall(s) (1 of 1)**

### **Outfall**

---

Use the map below to find the outfall. Drag and drop the location icon to the outfall location, and the coordinates will be automatically filled in on the form. For additional outfalls, click on the "+" tab at top of page.

**Outfall Number**

001

**Outfall Location**

34.695139,-92.152056

NONE PROVIDED

**Description of outfall location**

1,346 linear feet due east from an existing Gate Structure, which is located within 100 feet from the southeast corner of the southernmost Sludge Storage Lagoon.

**Name of Receiving Stream?**

Arkansas River in Segment 3C of the Arkansas River Basin.

**Facility location map**

[Vicinity Map.pdf - 12/14/2020 11:02 AM](#)

**Comment**

NONE PROVIDED

**Topographic map**

[USGS Quadrangular Map.pdf - 12/14/2020 11:03 AM](#)

**Comment**

NONE PROVIDED

## **Section B2- Monitoring Location(s) (1 of 2)**

### **Monitoring Station Information**

---

Enter information below that identifies and describes the location of the monitoring station for the outfall. If there is more than one outfall and monitoring station, click the "+" tab above to enter additional information for additional monitoring stations.

THE INFORMATION IN THIS SECTION MUST BE ENTERED EVEN IF THE MONITORING STATION IS LOCATED AT THE OUTFALL.

Enter the corresponding Outfall Number for the monitoring station. For example: if the monitoring station is for sampling the discharge from Outfall 01A, enter "01A" as the Monitoring Station Number.

Enter a physical description of the location of the Monitoring Station. For Example: "after the chlorine contact chamber", or "at the outfall".

Use the map below to find the monitoring station coordinates. Drag and drop the location icon to the monitoring station location, and the coordinates will be automatically filled in on the form.

**Monitoring Station Number**

001

**Enter a description of the location of the Monitoring Station**

Except for TRC and WET; after the chlorine contact basin just prior to pipeline to Arkansas River

**Monitoring Station Coordinates**

34.697528,-92.165694

NONE PROVIDED

**Section B2- Monitoring Location(s) (2 of 2)****Monitoring Station Information**

---

Enter information below that identifies and describes the location of the monitoring station for the outfall. If there is more than one outfall and monitoring station, click the "+" tab above to enter additional information for additional monitoring stations.

THE INFORMATION IN THIS SECTION MUST BE ENTERED EVEN IF THE MONITORING STATION IS LOCATED AT THE OUTFALL.

Enter the corresponding Outfall Number for the monitoring station. For example: if the monitoring station is for sampling the discharge from Outfall 01A, enter "01A" as the Monitoring Station Number.

Enter a physical description of the location of the Monitoring Station. For Example: "after the chlorine contact chamber", or "at the outfall".

Use the map below to find the monitoring station coordinates. Drag and drop the location icon to the monitoring station location, and the coordinates will be automatically filled in on the form.

**Monitoring Station Number**

001

**Enter a description of the location of the Monitoring Station**

For TRC and WET, at the final sluice gate on the 72" effluent pipeline to AR River

**Monitoring Station Coordinates**

34.695333,-92.157472

NONE PROVIDED

**Section B3 - Treatment System Information****Type of Treatment System**

Construction will be new walls within an equalization basin holding industrial wastewater that is accepted and permitted through our Pretreatment Program.

**Process Flow Diagram - Include all components of the treatment system**

[Process Description.pdf - 12/14/2020 11:03 AM](#)

[Process Flow Schematic.pdf - 12/14/2020 11:03 AM](#)

[Process Flow Scheme.pdf - 12/14/2020 11:03 AM](#)

[Process Flow Schematic 48 MGD.pdf - 12/14/2020 11:03 AM](#)

**Comment**

NONE PROVIDED

**Do you have, or plan to have, automatic sampling equipment or continuous wastewater flow metering equipment at this facility?**

Yes, Currently, Automatic Sampling Equipment

**If "Yes" was selected in previous section, please indicate present or future location of this equipment on the process flow diagram and describe the equipment below.**

Refrigerated automatic samplers; final effluent samples are collected at the final effluent weir. Grab samples are also collected as needed for process control.

**Is the proposed or existing facility located above the 100-year flood level?**

YES

**If "No" was selected, what measures are (or will be) used to protect the facility?**

NONE PROVIDED



**100-year Flood Zone FEMA Map**

FEMA Map.pdf - 12/14/2020 11:03 AM

**Comment**

NONE PROVIDED

**Are there permanent backup generators?**

YES

**If "Yes", how many and what is the total horsepower (HP)? If "No", please explain.**

Two; total horsepower is 1,554.

**Population for Municipal Sewer Systems:**

47975

**Section C - Waste Storage and Disposal Information**

---

**Sludge Disposal Method**

---

Fill in all necessary information for each sludge disposal method below.

**Landfill Disposal**

---

**Landfill**

No

**Landfill Site Name**

NONE PROVIDED

**Landfill - ADEQ Solid Waste Permit Number**

NONE PROVIDED

**Land Application Disposal**

---

**Land Application**

Yes

**Land Application - ADEQ State Permit Number**

ARL040177

**Distribution and Marketing Disposal**

---

**Distribution and Marketing**

No

**Name of Facility Receiving Sludge**

NONE PROVIDED

**Mailing Address**

[NO STREET ADDRESS SPECIFIED]

[NO CITY SPECIFIED], [NO STATE SPECIFIED] [NO ZIP CODE SPECIFIED]

**Method of Sludge Transport**

NONE PROVIDED

**Subsurface Disposal (Lagooning)**

No

**Subsurface Disposal - Lagooning**

---

Subsurface Disposal refers to sludge being stored in a sludge storage lagoon.

**Location of Lagoon**

NONE PROVIDED

**How old is the lagoon(s) (years)?**

NONE PROVIDED

**Surface area of lagoon (Acres)?**

NONE PROVIDED

**Average Depth of Lagoon (ft)?**

NONE PROVIDED

**Does lagoon have liner?**

NONE PROVIDED

**Incineration**

---

**Is incineration used?**

No

**Location of incinerator**

NONE PROVIDED

**Remains in Treatment Lagoon(s)**

---

**Remains in Treatment Lagoon(s)?**

No

**How old is the lagoon(s) (years)?**

NONE PROVIDED

**Has sludge depth been measured?**

NONE PROVIDED

**If No, when will it be measured?**

NONE PROVIDED

**If Yes, Date measured?**

NONE PROVIDED

**Average Sludge Depth (ft)?**

NONE PROVIDED

**Has sludge ever been removed?**

NONE PROVIDED

**If Yes, when was it removed?**

NONE PROVIDED

**Other Disposal Method**

---

**Other Method of Sludge Disposal**

Yes

**Description of alternative disposal method**

Thickened sludge is stabilized by anaerobic digestion with biogas recovery, lagoon storage, and land application by third party contract.

**Section D - Water Supply**

---

**Water Supply Sources**

---

**Water Sources within 5 miles**

None

**Water Sources within 50 miles**

Municipal Water Utility

**Specify Municipal Water Utilities within 50 miles (if applicable) - If there is not enough space, attach list below.**

Central Arkansas Water

**Attach list of Municipal Water Utilities within 50 miles, if necessary.**

NONE PROVIDED

**Comment**

NONE PROVIDED

**Location**

NONE PROVIDED

NONE PROVIDED

---

**Section H - Technical Information - Construction Permit or Modification of Treatment System**

---

**Include Technical information to support this application in enough detail to understand the project. Information in this part is required for obtaining a construction permit or for modification of the treatment system.**

---

**1. Describe the treatment system. Include the types of control equipment to be installed along with their methods of operation and control efficiency.**

This project will repair and reconfigure an equalization basin that attenuates flows from a local industry permitted through the City's Pretreatment Program. See Section H - Technical Information document (attached below) for a more detailed statement.

---

2. One set of construction plans and specifications, approved (Signed and stamped) by a Professional Engineer (PE) registered in Arkansas, must be submitted as follows:

A. The plans must show flow rates in addition to pertinent dimensions so that detention times, overflow rates, and loadings per acre, etc. can be calculated.

B. Specifications and complete design calculations.

C. All treated wastewater discharges should have a flow measuring device such as a weir or Parshall flume installed. Where there is a significant difference between the flow rates of the raw and treated wastewater, a flow measuring device should be provided both before and after treatment.

---

3. If this application includes a construction permit disturbing five or more acres, a storm water construction permit must be obtained by submitting a notice of intent (NOI) to ADEQ.

**Attach Construction Documents**

[LRWRA Active Permits.pdf - 12/14/2020 11:04 AM](#)

[Combined Preliminary Specs.pdf - 12/21/2020 01:39 PM](#)

[Combined Preliminary Plans.pdf - 12/21/2020 01:39 PM](#)

[Section H Description.pdf - 12/21/2020 01:40 PM](#)

**Comment**

NONE PROVIDED

---

**Attachments**

---

Date	Attachment Name	Context	User
12/21/2020 1:40 PM	Section H Description.pdf	Attachment	Jamie Ewing

Date	Attachment Name	Context	User
12/21/2020 1:39 PM	Combined Preliminary Specs.pdf	Attachment	Jamie Ewing
12/21/2020 1:39 PM	Combined Preliminary Plans.pdf	Attachment	Jamie Ewing
12/14/2020 11:04 AM	LRWRA Active Permits.pdf	Attachment	Jamie Ewing
12/14/2020 11:03 AM	FEMA Map.pdf	Attachment	Jamie Ewing
12/14/2020 11:03 AM	Process Flow Schematic.pdf	Attachment	Jamie Ewing
12/14/2020 11:03 AM	Process Flow Scheme.pdf	Attachment	Jamie Ewing
12/14/2020 11:03 AM	Process Flow Schematic 48 MGD.pdf	Attachment	Jamie Ewing
12/14/2020 11:03 AM	Process Description.pdf	Attachment	Jamie Ewing
12/14/2020 11:03 AM	USGS Quadrangular Map.pdf	Attachment	Jamie Ewing
12/14/2020 11:02 AM	Vicinity Map.pdf	Attachment	Jamie Ewing

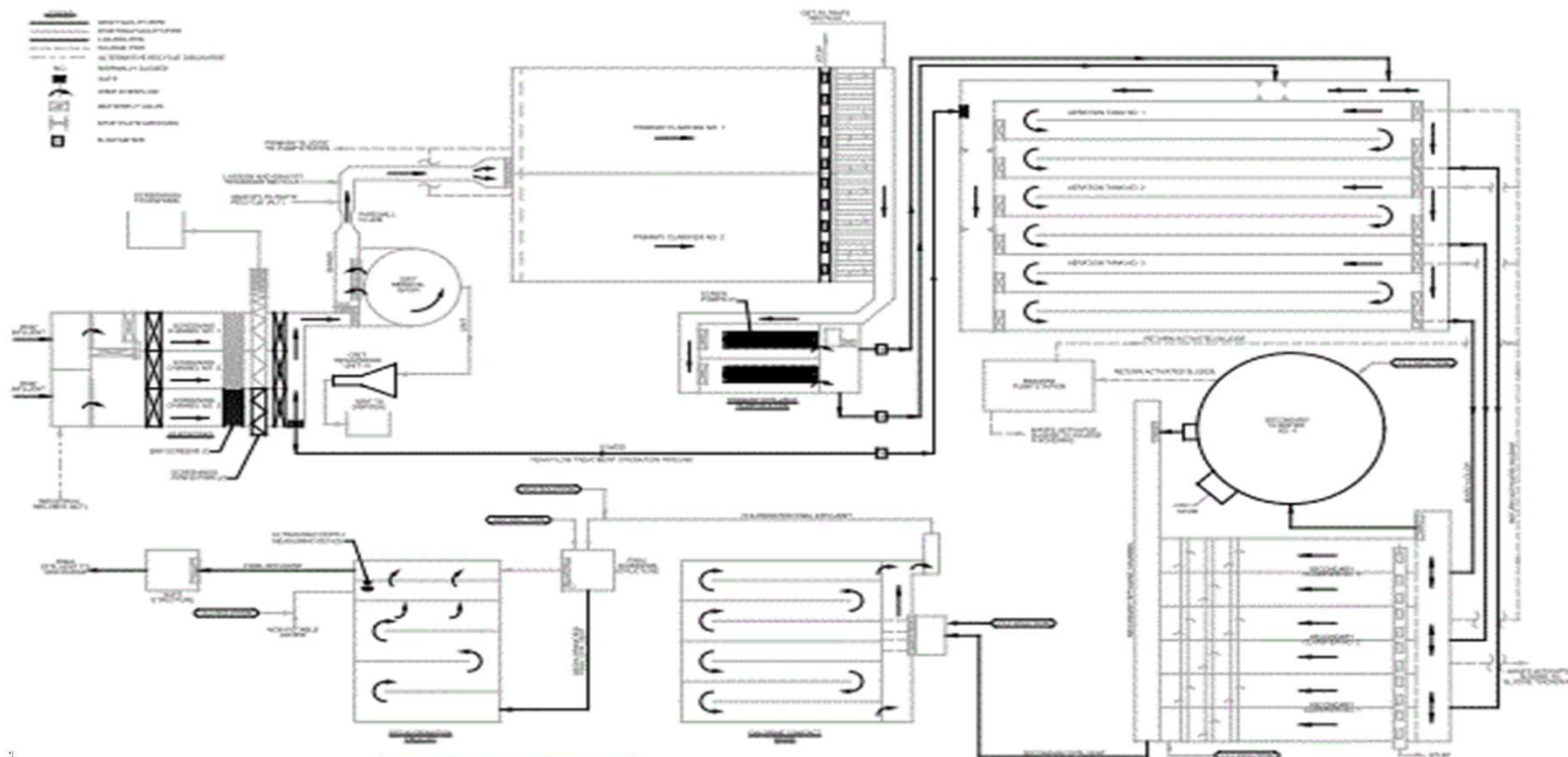
## Status History

	User	Processing Status
12/9/2020 1:45:02 PM	Jamie L Ewing	Draft
12/21/2020 1:53:58 PM	Gregorio Ramon	Submitted

## Processing Steps

Step Name	Assigned To/Completed By	Date Completed
Initial Application Processing - AA	Gregorio Ramon	12/21/2020 1:53:58 PM
Application Processing - AA	Amanda Blackmon	
Review of Application for Administrative Completeness	Loretta Carstens	
Draft Administratively Incomplete letter	Loretta Carstens	
Mail Administratively Incomplete letter - AA	Amanda Blackmon	
Application deemed Administratively Complete	Loretta Carstens	
Draft Administratively Complete letter & finish application processing - AA	Amanda Blackmon	
Review and sign Administratively Complete letter - Engineer Supervisor		
Mail Adminstratively Complete letter - AA	Amanda Blackmon	
Contact newspaper and publish Public Notice of Administratively Complete Application - AA	Amanda Blackmon	
TECHNICAL REVIEW OF APPLICATION - Drafting Permit		
PRIORITY - All plans, specs, and calcs stamped by AR Reg PE?		
Inspections reviewed, if applicable		
Invoices reviewed		
REVIEW DESIGN - ADH flow values and sand filters - 10 SS for all components		
Facility, Outfall, and Monitoring locations verified & plotted on Google Earth		

Step Name	Assigned To/Completed By	Date Completed
Check COMPLETE Receiving Stream, HUC+Reach, River Basin, Segment, Ecoregion, TMDL, 303(d), ERW, ESW, NSW, Trout, Nutrient Surplus, ORW Exclusion on ArcGIS map & VERIFY		
Run USGS Stream Stats for Drainage Area, 7Q10, critical stream miles, etc.		
Review downstream water supplies		
Write Draft Permit		
In-house review of draft construction permit - Peer Review		
Proofreading	Brenda Hughes	
Review of comments - Permit Engineer		
In-house review of draft construction permit - Engineer Supervisor		
In-house review of draft construction permit - Senior Operations Manager	Bryan Leamons	
Print out draft construction permit LETTER and give to Associate Director for signature - Permit Engineer		
DRAFT Review - SIGNATURE - Associate Director	Caleb Osborne	
Remove "For Internal Review" from pre-draft permit, clean up pagination, etc. - Permit Engineer		
Submit Pre-draft Construction Permit for 5-day review by permittee - Engineer		
Receive 5-day review permittee comments - Permit Engineer		
Prepare Request for Invoice (if required) - AA	Amanda Blackmon	
Contact newspaper and publish Public Notice of Draft Construction Permit - AA	Amanda Blackmon	
Close of Public Notice - Permit Engineer	Hannah Gage	
If Public Meeting/Public Hearing requested, insert "Public Meeting/Public Hearing" template - Permit Engineer		
Prepare Response to Comments (as required) and Final Construction Permit - Permit Engineer		
Verify Proof of Publication and Payment, Cover Page Dates, FA Received (if app.), Remove Draft Watermark & PN paragraph, Make Changes in Database, and Attach Final Compliance Review - Permit Engineer		
In-house Review of Response to Comments & Final Construction Permit - 208 Plan Review	Shane Byrum	
Verify All Fees Paid and Check Fee Code in PDS - AA	Amanda Blackmon	
In-house Review of Response to Comments & Final Construction Permit - Engineer Supervisor		
In-house Review of Response to Comments & Final Construction Permit - Senior Operations Manager	Bryan Leamons	
Print out final construction permit and give to Associate Director - Permit Engineer		
FINAL Review - SIGNATURE - Associate Director	Caleb Osborne	
Prepare & sign certification letter and mail permit documents - AA	Amanda Blackmon	



Tank Description	Number of Tanks	Total Volume (MG)
Primary Clarifiers	2	1.87
Aeration Basins	3	2.61
Rectangular Clarifiers	3	2.1
Circular Clarifier	1	3.3
CL2 Contact	2	0.8
SO2 Contact	1	0.15

Peak Hydraulic Flow 48.00 MGD	Average Daily Detention Time (Hours)
per Tank (MGD)	Total Time
18.0	1.2
16.0	1.3
6.4	7.9
28.8	3.3
24.0	0.4
48.0	0.1



NTS

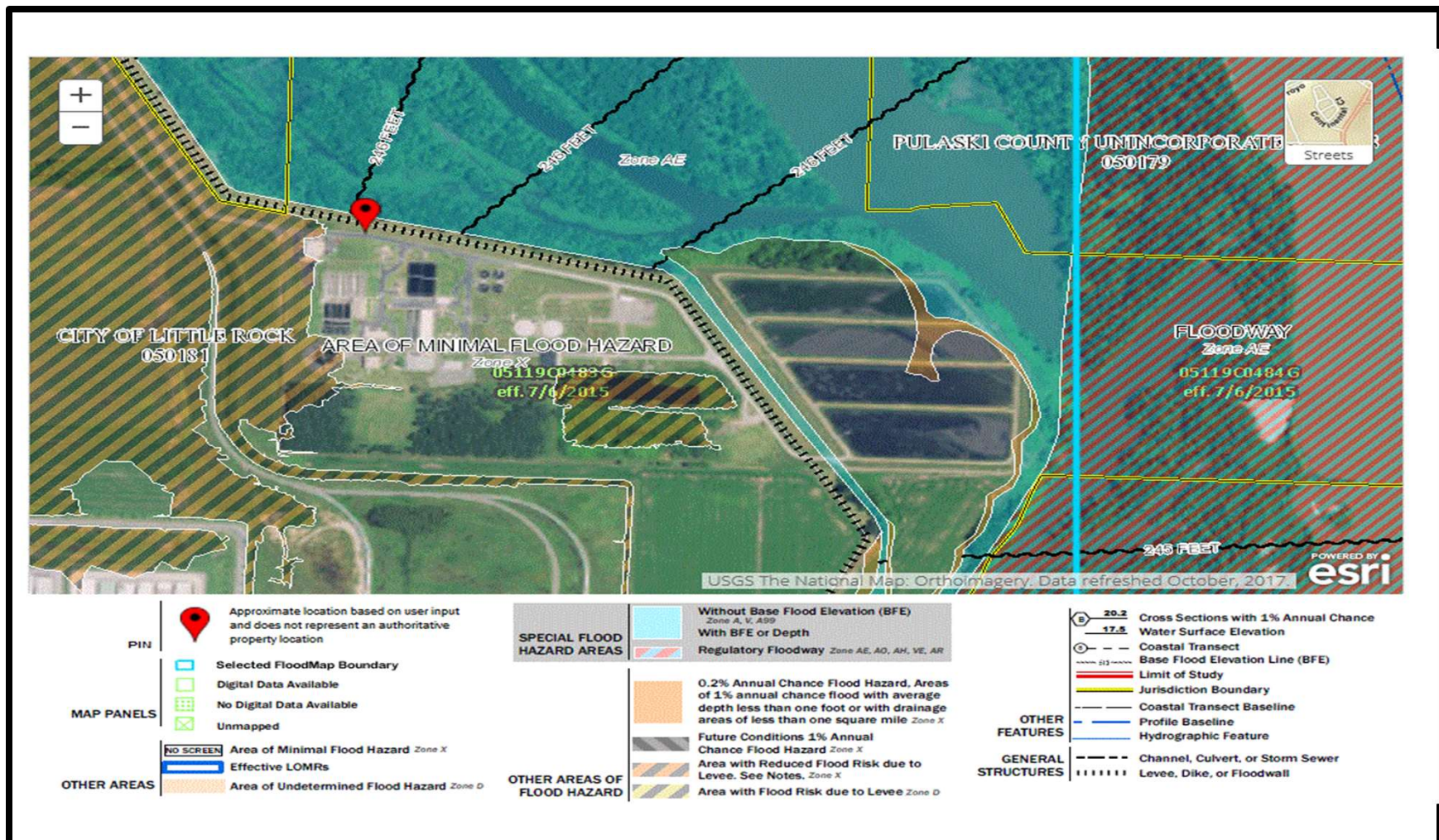
**Fourche Creek WRF**  
 Little Rock, Arkansas Telephone 501-490-5400  
 Section 13, T-1-N, R-13-W Pulaski County  
 Outfall Location

34 deg., 41 min., 42.5 sec., Latitude  
 -92 deg., 09 min., 07.4 sec., Longitude

**Process  
 Flow Diagram**  
 Flows - 48 MGD Maximum







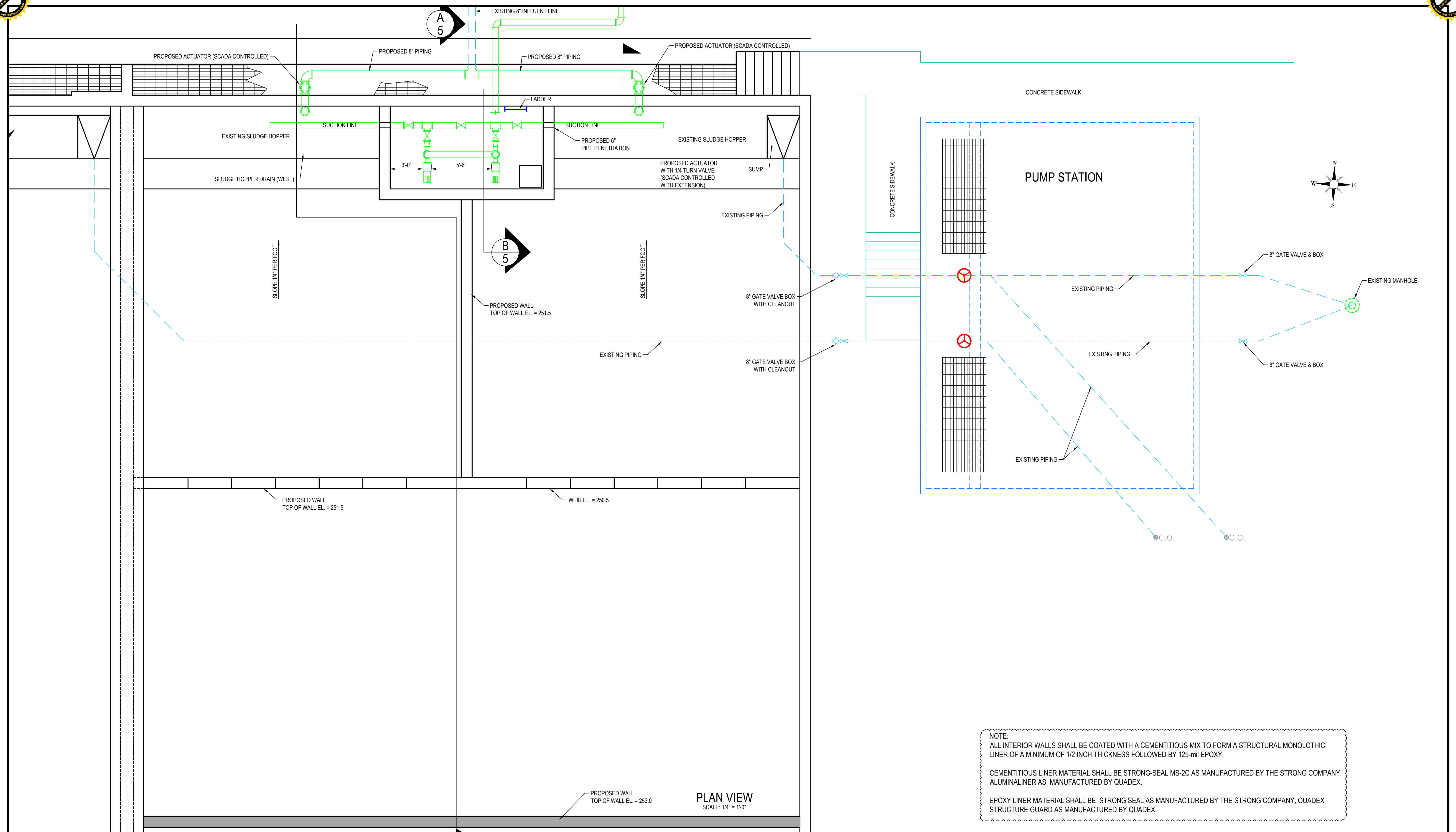
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 Section 13, T-1-N, R-13-W Pulaski County  
 Outfall Location  
 34 deg., 41 min., 42.5 sec., Latitude  
 -92 deg., 09 min., 07.4 sec., Longitude

## Facility Location FEMA Floodplain Map









NOTE:  
ALL INTERIOR WALLS SHALL BE COATED WITH A CEMENTITIOUS MIX TO FORM A STRUCTURAL MONOLITHIC LINER OF A MINIMUM OF 1/2 INCH THICKNESS FOLLOWED BY 125-mil EPOXY.

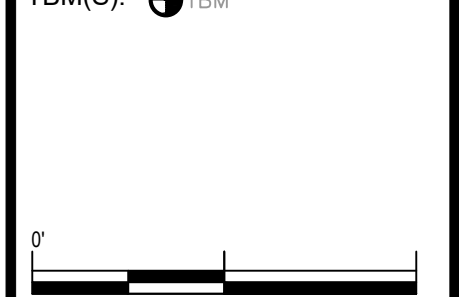
CEMENTITIOUS LINER MATERIAL SHALL BE STRONG-SEAL MS-2C AS MANUFACTURED BY THE STRONG COMPANY, ALUMINALINER AS MANUFACTURED BY QUADEX.

EPOXY LINER MATERIAL SHALL BE STRONG SEAL AS MANUFACTURED BY THE STRONG COMPANY, QUADEX STRUCTURE GUARD AS MANUFACTURED BY QUADEX.



1. FIELD VERIFY AND MARK LOCATIONS OF "ALL" EXISTING (E) UTILITIES AS WELL AS ELEVATIONS PRIOR TO ANY CONSTRUCTION.
2. EXISTING (E) SERVICE LINE LOCATIONS ARE APPROXIMATE. DETERMINATION SHALL BE MADE IN THE FIELD AS TO THE LOCATIONS AND WHETHER SERVICE IS "LIVE" OR "DEAD". REINSTATE "LIVE" SERVICES ONLY.
3. DATA CONTAINED IN THE PLAN VIEW PORTION OF THIS SHEET WAS COMPILED FROM VARIOUS SOURCES FOR THE SOLE USE AND BENEFIT OF THE PULASKI AREA. GEOGRAPHIC INFORMATION SYSTEM (PAIS) AND THE PUBLIC AGENCIES IT SERVES. IT IS A PERSPECTIVE REPRESENTATION BASED MAP ONLY. USE GIVEN DISTANCES ALONG WITH PROFILE INFORMATION. DO NOT SCALE PLAN VIEW.

LRW  
MAP BOOK  
PAGE(S)  
REFERENCE:



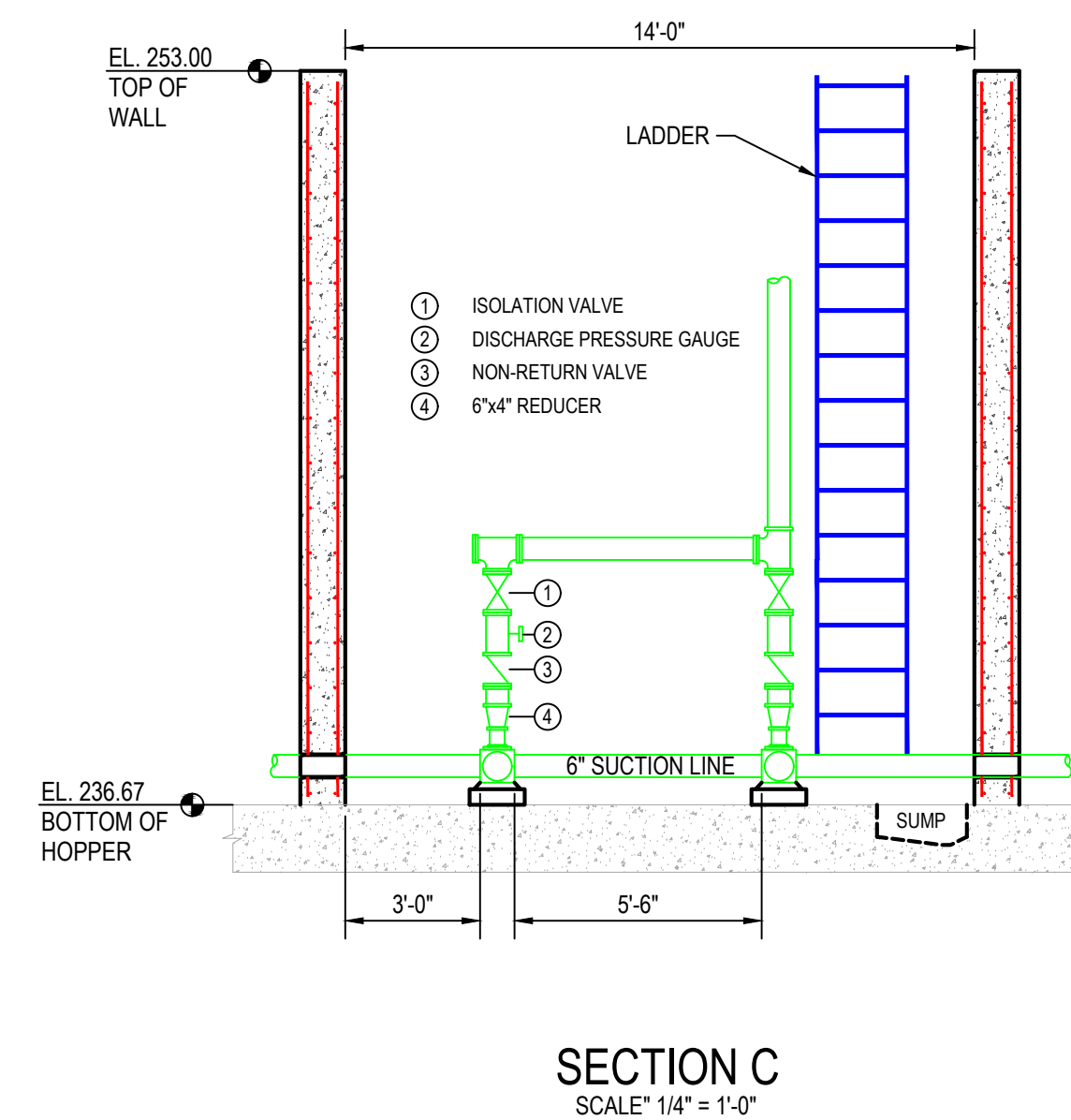
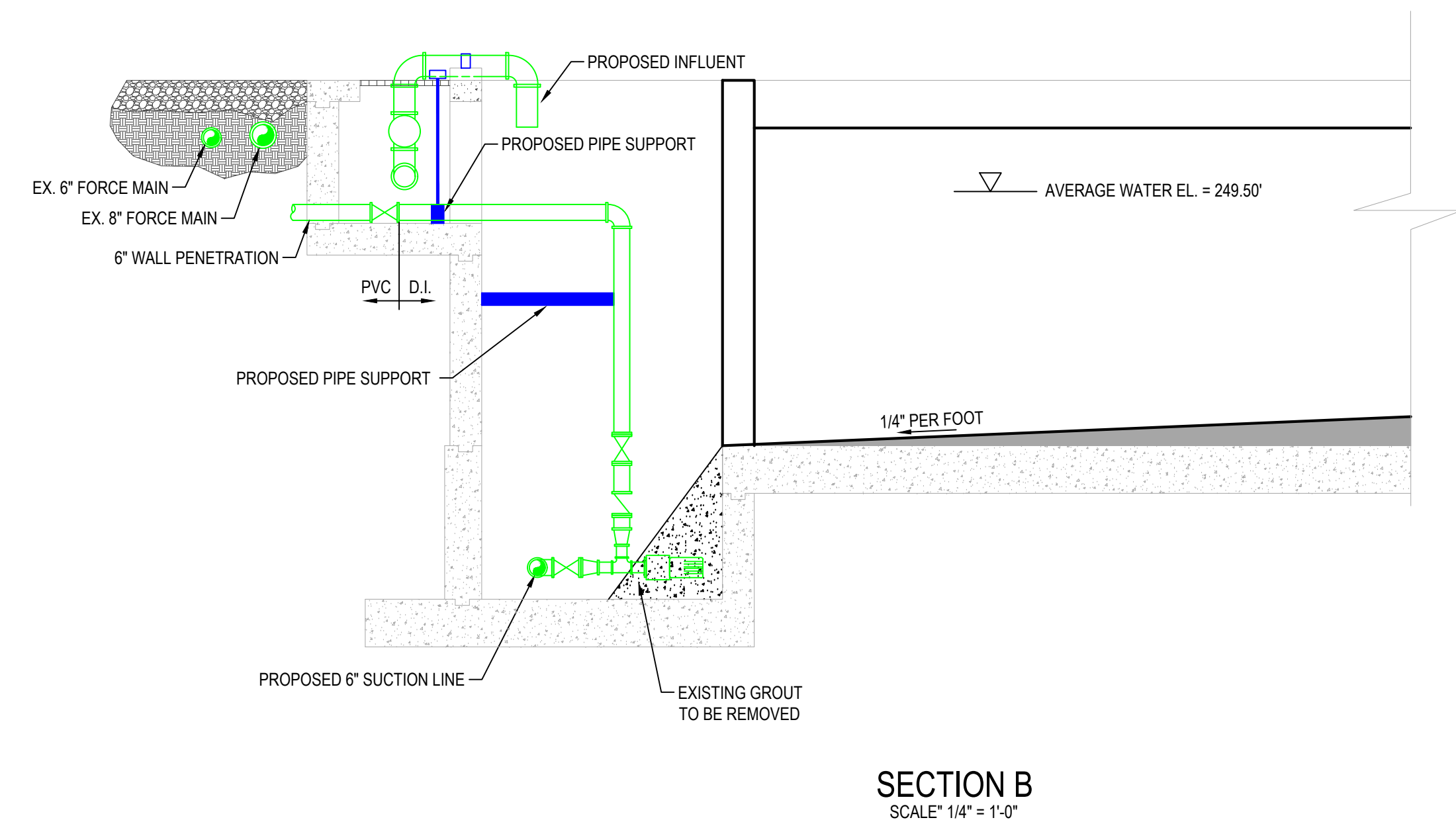
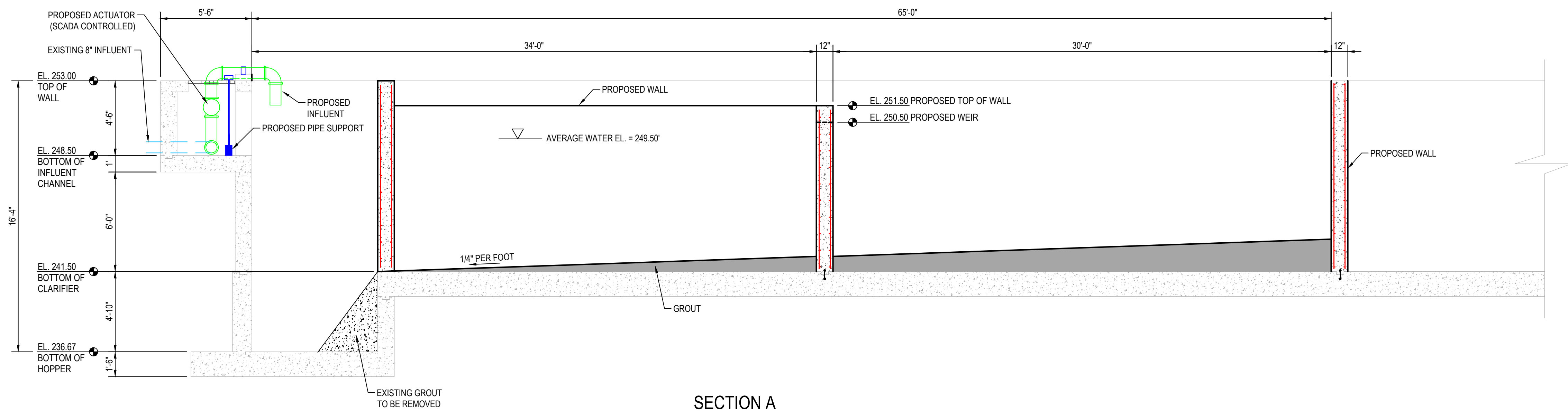
PROJECT #: 7190700  
ENGINEER TECH: S. Taylor  
PROGRAM MANAGER: J. Holloway  
REVISED BY:  
DATE: 12/4/20  
AS-BUILT DONE BY:  
DATE:  
CAD FILE: 004



**PLAN VIEW**  
**INDUSTRIAL EQ STORAGE BASIN REHABILITATION**  
FOURCHE CREEK WATER RECLAMATION FACILITY

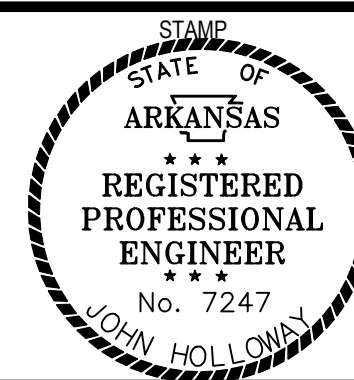
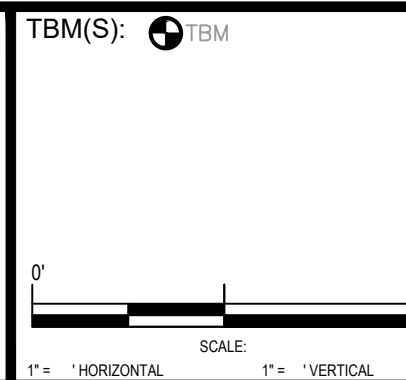
SHEET  
NUMBER  
**3**  
OF





1. FIELD VERIFY AND MARK LOCATIONS OF "ALL" EXISTING (E) UTILITIES AS WELL AS ELEVATIONS PRIOR TO ANY CONSTRUCTION.
2. EXISTING (E) SERVICE LINE LOCATIONS ARE APPROXIMATE. DETERMINATION SHALL BE MADE IN THE FIELD AS TO THE LOCATIONS AND WHETHER SERVICE IS "LIVE" OR "DEAD". REINSTATE "LIVE" SERVICES ONLY.
3. DATA CONTAINED IN THE PLAN VIEW PORTION OF THIS SHEET WAS COMPILED FROM VARIOUS SOURCES FOR THE SOLE USE AND BENEFIT OF THE PULASKI AREA GEOGRAPHIC INFORMATION SYSTEM (PAGIS) AND THE PUBLIC AGENCIES IT SERVES. IT IS A PERSPECTIVE REPRESENTATION BASED MAP ONLY. USE GIVEN DISTANCES ALONG WITH PROFILE INFORMATION. DO NOT SCALE PLAN VIEW.

LRW  
MAP BOOK  
PAGE(S)  
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PROJECT #: 7190700  
ENGINEER TECH.: S. Taylor  
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REVISED BY:  
DATE: 12/4/20  
AS-BUILT DONE BY:  
DATE:  
CAD FILE: 004

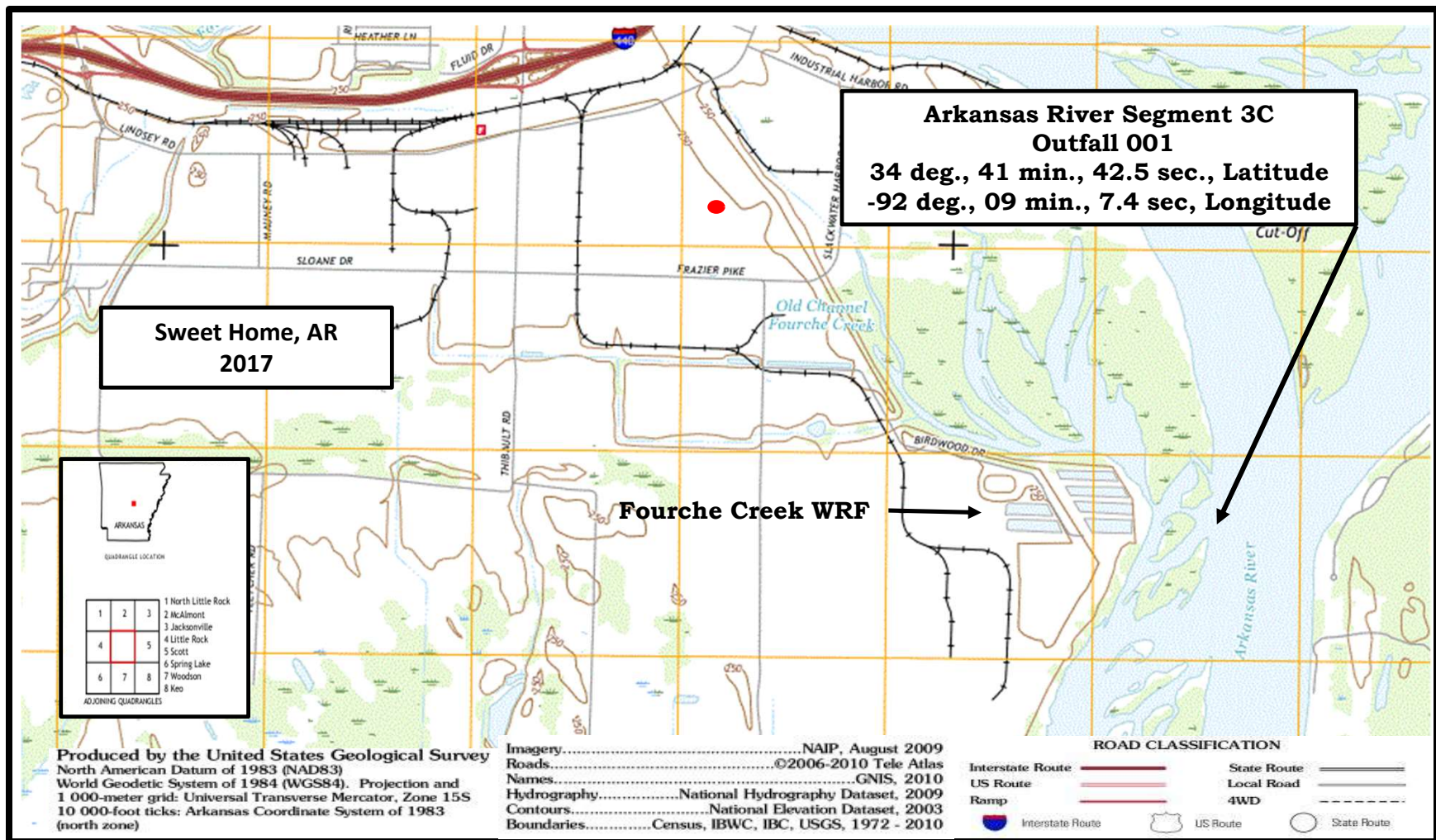


## TYPICAL SECTIONS INDUSTRIAL EQ STORAGE BASIN REHABILITATION

FOURCHE CREEK WATER RECLAMATAION FACILITY

SHEET  
NUMBER  
**5**  
OF

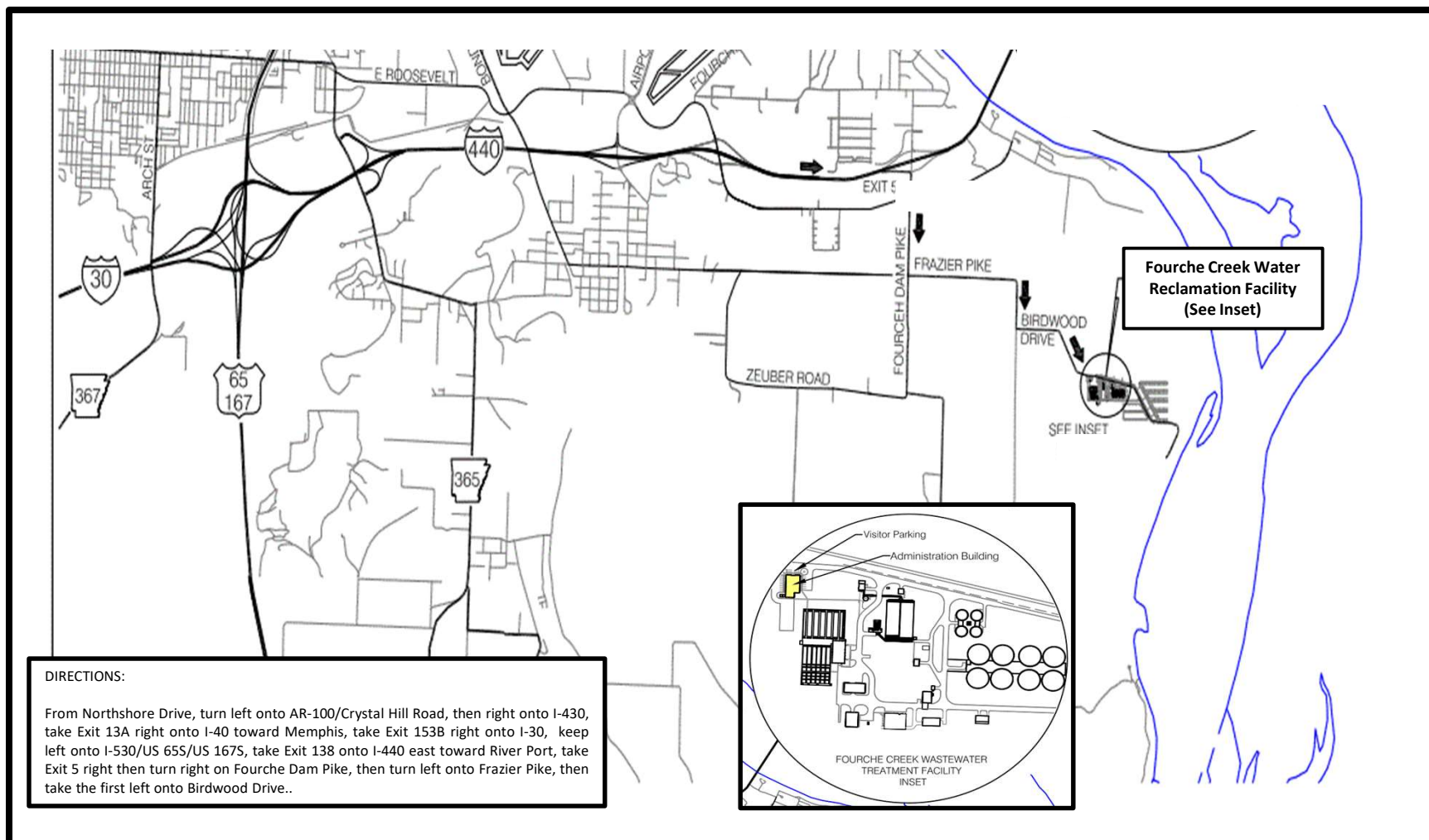




**Fourche Creek WRF**  
Little Rock, Arkansas Telephone 501-490-5400  
Section 13, T-1-N, R-13-W Pulaski County  
Outfall Location  
34 deg., 41 min., 42.5 sec., Latitude  
-92 deg., 09 min., 7.4 sec., Longitude

**Facility Location  
USGS  
Quadrangular Map**





**Fourche Creek WRF**  
**Little Rock, Arkansas Telephone 501-490-5400**  
**Section 13, T-1-N, R-13-W Pulaski County**  
**Outfall Location**  
**34 deg., 41 min., 42.5 sec., Latitude**  
**-92 deg., 09 min., 07.4 sec., Longitude**

## Facility Location Vicinity Map and Directions



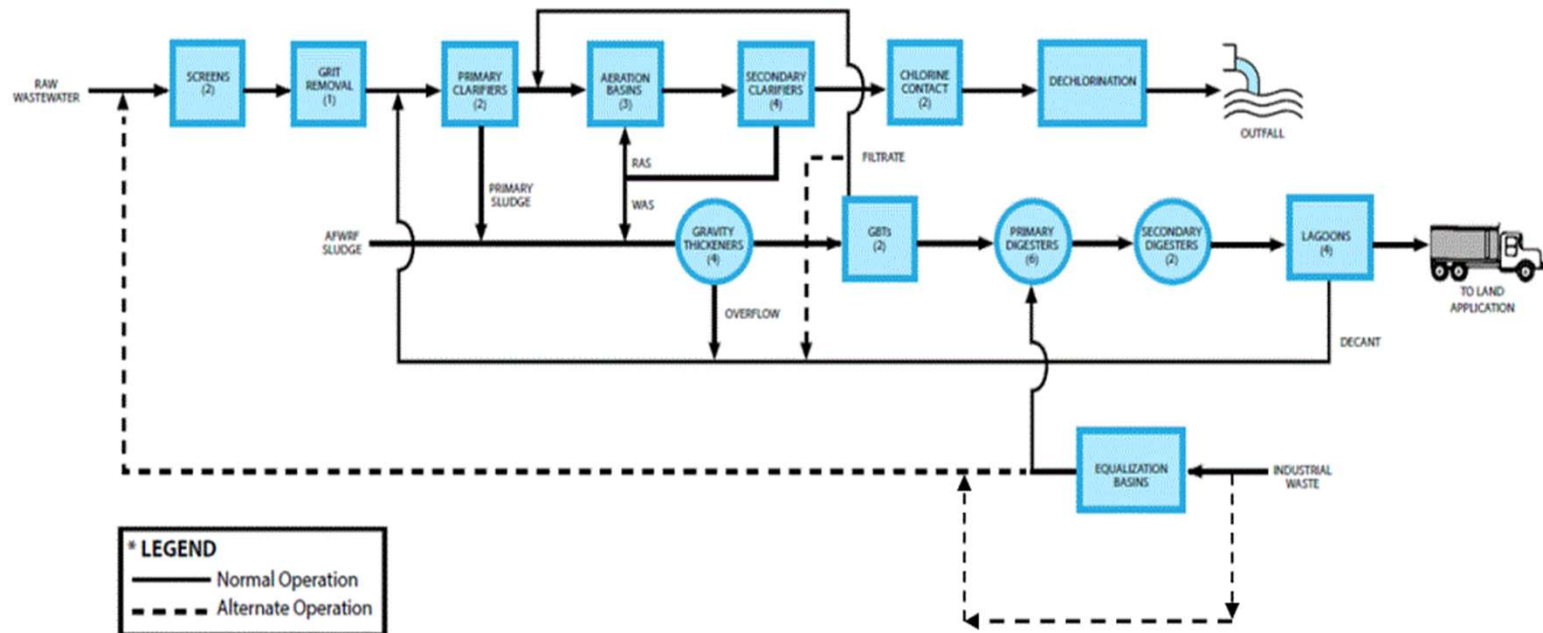
## **Section H – Technical Information**

- 1. Describe the treatment system. Include the types of control equipment to be installed along with their methods of operation and control efficiency.**

**The applicant desires to rehabilitate and modify the existing industrial equalization basin that currently attenuates flows from local industries. See attached Technical Information Document.**

This project will address degrading concrete as well as provide plant staff variability in the operating scheme. Additionally, these modifications will allow the equalization basin to receive flows from other future industrial contributors.

This project consists of cleaning and coating of both existing and proposed concrete walls, crack injection to the existing concrete walls, reconfiguration of the attenuation scheme of the flows, a new pump station and some yard piping. This project will also include the diversion of flows into temporary storage tanks for storage during construction. This will allow the industrial user to remain fully operational throughout the rehabilitation of this equalization basin.



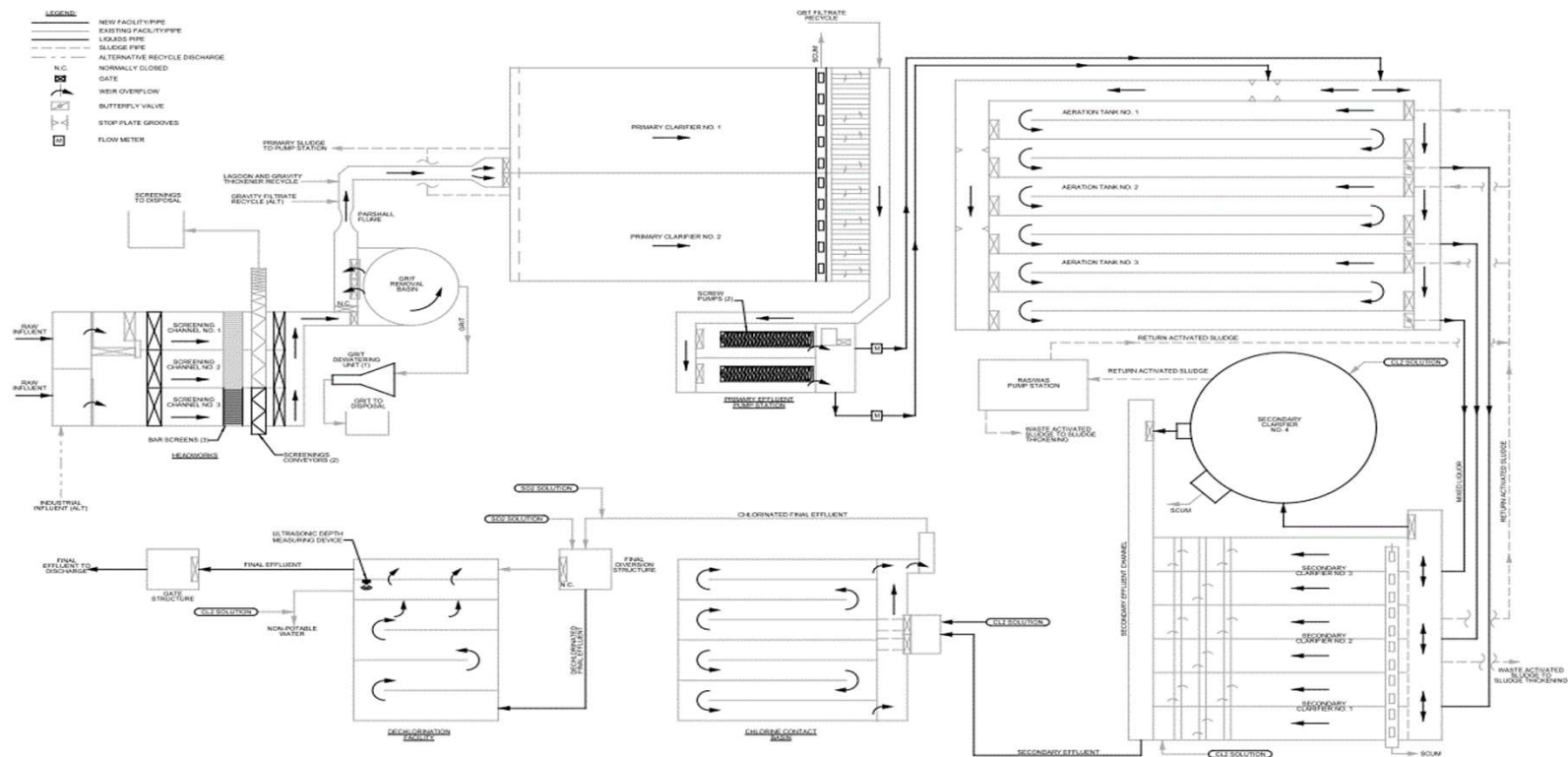
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**Fourche Creek WRF**  
 Little Rock, Arkansas Telephone 501-490-5400  
 Section 13, T-1-N, R-13-W Pulaski County  
 Outfall Location  
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## Process Flow Schematic







NTS

**Fourche Creek WRF**  
 Little Rock, Arkansas Telephone 501-490-5400  
 Section 13, T-1-N, R-13-W Pulaski County  
 Outfall Location  
 34 deg., 41 min., 42.5 sec., Latitude  
 -92 deg., 09 min., 07.4 sec., Longitude

**Process  
 Flow Diagram**  
 Average, Design, Peak  
 Existing Flows







## DOCUMENT 00200

### INFORMATION FOR BIDDERS

#### 1. **DEFINED TERMS**

- 1.1 Terms used in these Information for Bidders which are defined in the Standard General Conditions and Supplemental General Conditions of the Construction Contract have the meanings assigned to them in the Supplemental and/or General Conditions. The term "Bidder" means one who submits a Bid directly to Owner, as distinct from Sub-Bidder, who submits a Bid to a Bidder. The term "Successful Bidder" means the lowest, qualified, responsible and responsive Bidder to whom Owner (on the basis of Owner's evaluation as hereinafter provided) makes an award. The term "Bidding Documents" includes the Advertisement or Invitation to Bid, Information for Bidders, the Bid Form, and the proposed Contract Documents (including all Addenda issued prior to receipt of Bids).
- 1.2 The term "Owner" means the Little Rock Water Reclamation Commission acting by and through Little Rock Water Reclamation Authority.

#### 2. **PROJECT FUNDING**

- 2.1 Project will be a combination of revenue funding and donated funds.

#### 3. **COPIES OF BIDDING DOCUMENTS**

- 3.1 Contract Documents for this Project have been made available to certain plan services. This distribution is made only as a convenience to potentially interested parties and is not intended as a mechanism for distributing bidding documents. Only hard copy versions of the Contract Documents, obtained directly from the Owner, will be accepted for bidding purposes.
- 3.2 Complete sets of Bidding Documents may be obtained from the Owner.
- 3.3 Complete sets of Bidding Documents shall be used in preparing Bids; the Owner does not assume any responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bidding Documents.
- 3.4 The Owner in making copies of Bidding Documents available on the above terms do so only for the purpose of obtaining Bids on the Work and do not confer a license or grant for any other use.



## **QUALIFICATIONS OF BIDDERS**

- 4.1 Each Bid must contain evidence of Bidder's qualifications to do business in the State of Arkansas or covenant to obtain such qualification prior to award of the Contract.

## **5. EXAMINATION OF CONTRACT DOCUMENTS AND SITE**

- 5.1 It is the responsibility of each Bidder before submitting a Bid, to (a) examine the Contract Documents thoroughly, (b) visit the site to become familiar with local conditions that may affect cost, progress, performance or furnishing of the Work, (c) consider Federal, State and Local Laws and Regulations that may affect cost, progress, performance or furnishing of the Work, (d) study and carefully correlate Bidder's observations with the Contract Documents, and (e) notify Owner of all conflicts, errors or discrepancies in the Contract Documents. The failure or omission of any Bidder to do any of the foregoing shall in no way relieve any Bidder from any obligation in respect to its Bid.
- 5.2 Bidders must satisfy themselves as to the estimated quantities in the Bid schedule by examination of the site and review of the Drawings and the Specifications, including Addenda. After Bids have been submitted, the Bidder shall not assert that there was a misunderstanding concerning the quantities of Work or of the nature of the Work to be done. Bidders shall acknowledge receipt of Addenda in the space provided on the Bid Form.
- 5.3 Information and data reflected in the Contract Documents with respect to Underground Facilities at or contiguous to the site is based upon information and data furnished to the Owner by owners of such Underground Facilities or others, and Owner does not assume responsibility for the accuracy or completeness thereof, unless it is expressly provided otherwise in the RLF Supplemental General Conditions.
- 5.4 Before submitting a Bid, each Bidder shall be responsible to make or obtain such explorations, tests and data concerning physical conditions (surface, subsurface and Underground Facilities) at or contiguous to the site or otherwise, which may affect cost, progress, performance or furnishing the Work in accordance with the time, price and other terms and conditions of the Contract Documents.
- 5.5 On request in advance, Owner will provide each Bidder access to the site to conduct such explorations and tests as each Bidder deems necessary for submission of a Bid. Bidder shall fill all holes, clean up and restore the site to its former condition upon completion of such explorations. A representative of the Owner shall be present during all tests.
- 5.6 Easement width for sanitary sewer lines and manholes is 5 feet either side of the pipe. All additional lands and access thereto required for temporary construction facilities or storage of materials and equipment are to be provided by Contractor. Easements for permanent structures or permanent changes in existing structures



are to be obtained and paid for by Owner.

## **6. INTERPRETATIONS AND ADDENDA**

- 6.1 All questions about the meaning or intent of the Contract Documents are to be directed in writing to the Owner. Interpretations or clarifications considered necessary by Owner in response to such questions will be issued by Addenda mailed or delivered to all parties recorded by Owner as having received the Bidding Documents. Questions received less than ten (10) days prior to the date for opening of Bids may not be answered. Only questions answered by formal, written Addenda will be binding. Oral and other interpretations or clarifications will be without legal effect.
- 6.2 Prior to the deadline for receiving Bids, Addenda may also be issued to modify the Bidding Documents as deemed advisable by Owner.
- 6.3 The Contract Documents contain the provisions required for the construction of the Project. Information obtained from an officer, agent, or employee of the Owner or any other person shall not affect the risks or obligations assumed by the Contractor or relieve the Contractor from fulfilling any of the conditions of the Contract.

## **7. BID SECURITY**

- 7.1 Each Bid must be accompanied by Bid security made payable to Owner in an amount of five (5) percent of the Bidder's maximum Bid price and in the form of a certified or bank check or a Bid Bond (on form attached), issued by a surety.
- 7.2 The Bid security of the Successful Bidder will be retained until Bidder has executed the Agreement and furnished the required Contract security, whereupon the Bid security will be returned. If the successful Bidder fails to execute and deliver the Agreement and furnish the required Contract security within ten (10) days after the Notice of Award, Owner may annul the Notice of Award, and the Bid security of that Bidder will be forfeited. The Bid security of other Bidders whom Owner believes to have a reasonable chance of receiving the award may be retained by Owner until the earlier of the seventh (7<sup>th</sup>) day after the Effective Date of the Agreement or the sixty-first (61<sup>st</sup>) day after the Bid opening, whereupon Bid security furnished by such Bidders will be returned upon request of the Bidder. Bid security with Bids which are not competitive will be returned within seven (7) days after the Bid opening upon request of the Bidder.

## **8. CONTRACT TIME**

- 8.1 The number of days within which the Work is to be substantially completed and also completed and ready for final payment (the Contract Time) are set forth in the Agreement and these Contract Documents.

## **9. LIQUIDATED DAMAGES**



Provisions for liquidated damages, if any, are set forth in the Agreement.

## **10. SUBSTITUTE OR "OR EQUAL" ITEMS**

10.1 The products specified herein are the standard of quality for use on this project. For products which are specified by naming one or more manufacturers preceded by "equal to" or followed by "or equal," equivalent products by other manufacturers are acceptable, providing they meet or exceed all performance criteria of the specified materials.

## **11. SUBCONTRACTORS, SUPPLIERS, AND OTHERS**

11.1 Subcontractors shall be listed in Section 00434. Suppliers shall be listed, if required, on the Bid Form.

## **12. BID FORM**

12.1 The Bid Form is included with the Bidding Documents.

12.2 All Bids must be made on the required Bid form. All blank spaces for Bid prices must be filled in, in ink or typewritten, and the Bid form must be fully completed and executed when submitted. Only one copy of the Bid form is to be submitted.

12.3 The Bidder shall submit a "Lump Sum" or "Unit Price Bid" for each item in the Bid Form. Unit price amounts shall be applied to the estimated quantities of work under each item to provide a total price for each item, and the aggregate amount for all items shall be the "Total Bid". The "Total Bid" shall be inclusive of the cost of all materials, equipment, labor, insurance, profit, taxes, and overhead.

12.4 Bids by corporations must be executed in the corporate name by the president or a vice president (or other corporate officer accompanied by evidence of authority to sign) and the corporate seal must be affixed and attested by the secretary or an assistant secretary. The corporate address and state of incorporation must be shown below the signature.

12.5 Bids by partnerships must be executed in the partnership name and signed by a partner, whose title must appear under the signature and the official address of the partnership must be shown below the signature.

12.6 All names must be typed or printed below the signature.

12.7 The Bid shall contain an acknowledgment of receipt of all Addenda (the numbers of which must be filled in on the Bid Form.

12.8 The address, telephone number, and fax number if applicable for communications regarding the Bid must be shown.

12.9 A conditional or qualified Bid will not be accepted.



### 13. **SUBMISSION OF BIDS**

- 13.1 Bids will be received by the **Little Rock Water Reclamation Commission acting by and through Little Rock Water Reclamation Authority** (herein called the "Owner"), at the time and place as designated in the **ADVERTISEMENT FOR BIDS**; and then at said time and place publicly opened and read aloud.
- 13.2 The Contractor shall submit the following documents with the Bid: Bid Form (Section 00410), Bidder's Statement of Subcontractors (Section 00434) and the Bid Bond (Section 00430).
- 13.3 Each emailed bid shall be a black and white scan of the physical bid documents, to include bid bonds or certified/bank check. The Authority would prefer one email of no more than 25 MB per bidder. The electronic bids are the official bid documents. The only purpose for sending the physical copies is the need for original security documents. Only bidders who have sent their bids electronically before 2:00 pm on **February 25, 2021** will be accepted. Mailed bids must be submitted in an opaque sealed envelope, addressed to Little Rock Water Reclamation Authority. Each sealed envelope containing a Bid must be plainly marked on the outside as **BID ENCLOSED – FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQUALIZATION BASIN**. The sealed envelope should bear on the outside the Bidder's name, Bidder's business address, Bidder's Arkansas contractor's license number, and the name of the project for which the Bid is submitted.
- 13.4 All sections of the Contract Documents and Specifications Manual shall be filled out entirely and all necessary signatures are required before Bid Proposal will be read aloud. If the Contract Documents and Specifications Manual is discovered to be incomplete or missing signatures, the bid will be returned to the Bidder and excluded from the Bid Opening.
- 13.5 If forwarded by mail or other delivery system, the sealed envelope containing the Bid shall be enclosed in a separate envelope with the notation "BID ENCLOSED", addressed and mailed to:

**Little Rock Water Reclamation Authority  
ATTN: Harold Hounwanou, P.E.  
11 Clearwater Drive  
Little Rock, AR 72204**

- 13.6 Attorneys-in-fact who sign Bid Bonds or Payment Bonds and Performance Bonds must file with each Bond a certified and effective dated copy of their Power of Attorney. Attorneys-in-Fact that sign Bonds must be licensed to conduct business in the State of Arkansas.
- 13.7 Any Bid received after the time and date specified shall not be considered.



## **14. MODIFICATION AND WITHDRAWAL OF BIDS**

- 14.1 Bids may be modified or withdrawn by an appropriate document duly executed (in the manner that a Bid must be executed) and delivered to the place where Bids are to be submitted at any time prior to the opening of Bids.
- 14.2 If within twenty-four (24) hours after Bids are opened, any Bidder files a duly-signed, written notice with the Owner and promptly thereafter demonstrates to the reasonable satisfaction of Owner that there was a material and substantial mistake in the preparation of its Bid, that Bidder may withdraw its Bid and the Bid security will be returned. Thereafter, that Bidder will be disqualified from further bidding on the Work to be provided under the Contract Documents.

## **15. OPENING OF BIDS**

- 15.1 Bids will be opened and (unless obviously non-responsible) read aloud on a Microsoft Teams call. An abstract of the amounts of the base Bids and major alternates (if any) will be made available to the Bidders after the opening of Bids. Bids will be returned without being read aloud if all applicable portions of the Contract Documents are not met by the Bidder.

## **16. BIDS TO REMAIN SUBJECT TO ACCEPTANCE**

- 16.1 All Bids will remain subject to acceptance for sixty (60) days after the day of the Bid opening, but Owner may, in its sole discretion, release any Bid and return the Bid security prior to that date.

## **17. AWARD OF CONTRACT**

- 17.1 Owner reserves the right to reject any and all Bids, to waive any and all informalities and to negotiate Contract terms with the Successful Bidder, and the right to disregard all nonconforming, nonresponsive, unbalanced or conditional Bids. Also, Owner reserves the right to reject the Bid of any Bidder if Owner believes that it would not be in the best interest of the Project to make an award to that Bidder, whether because the Bid is not responsive or the Bidder is unqualified or of doubtful financial ability or fails to meet any other pertinent standard or criteria established by Owner. Discrepancies in the multiplication of units of Work and unit prices will be resolved in favor of the unit prices. Discrepancies between the indicated sum of any column of figures and the correct sum thereof will be resolved in favor of the correct sum.
- 18.2 In evaluating Bids, Owner will consider the qualifications of the Bidders, whether or not the Bids comply with the prescribed requirements, and such alternates, unit prices and other data, as may be requested in the Bid Form or prior to the Notice of Award. Owner may accept any such alternatives in any order or combination, whether in the order in which they are listed in the Bid Form or not.





- 18.4 Owner may conduct such investigations as deemed necessary to assist in the evaluation of any Bid and to establish the responsibility, qualifications and financial ability of Bidders, proposed Subcontractors, Suppliers and other persons and organizations to perform and furnish the Work in accordance with the Contract Documents to Owner's satisfaction within the prescribed time.
- 18.5 If the Contract is to be awarded, it will be awarded to the lowest Bidder whose evaluation indicates to Owner that the award will be in the best interest of the Project.
- 18.6 If the Contract is to be awarded, Owner will give the successful Bidder a Notice of Award within sixty (60) days after the day of the Bid opening. Should there be reasons why the Contract cannot be awarded within the specified period, the time may be extended by mutual agreement between the Owner and the Bidder.

## **19. CONTRACT SECURITY**

- 19.1 The General Conditions and Supplemental General Conditions set forth Owner's requirements as to Performance Bond, Payment Bond and a Warranty Bond. When the successful Bidder delivers the executed Agreement to Owner, it must be accompanied by the required Performance and Payment Bonds. At the time of Final Acceptance, the Contractor shall provide the Owner the Warranty Bond.
- 19.2 A Performance Bond and a Payment Bond each in the amount of one hundred (100) percent of the Contract Price, with a corporate surety approved by the Owner, will be required for the faithful performance of the Contract.

## **20. SIGNING OF AGREEMENT**

- 20.1 When Owner gives a Notice of Award to the successful Bidder, it will be accompanied by the required number of unsigned counterparts of the Agreement and all other written Contract Documents attached. Within ten (10) days thereafter Contractor shall sign and deliver the required number of counterparts of the Agreement and attached documents to Owner with the required Bonds. Within ten (10) days thereafter, Owner shall deliver one fully-signed counterpart to Contractor. Each counterpart is to be accompanied by a complete set of the Drawings with appropriate identification.

## **21. PRE-BID CONFERENCE**

- 21.1 A **non-mandatory** prebid conference will be hosted virtually at 2:00 pm on **February 18, 2021**. Contractors need to be able to use Microsoft Teams. An invitation for the Microsoft Teams meeting will be sent to the bidder representative's email that requested the bid documents unless a different representative email address is provided. Please send the preferred email address for the prebid meeting by email to Harold.Hounwanou@lrwa.com no later than 4:30 pm Central Standard Time on **February 17, 2021**. Representatives of Owner will be present to discuss the Project. Bidders are reminded that any



representations or understandings arising from Prebid Conference shall not supersede the written provision of the Contract Documents themselves.

## **22. RETAINAGE**

- 22.1 Provisions concerning retainage are set forth in the RLF Supplemental General Conditions.

## **23. SPECIAL LEGAL REQUIREMENTS**

- 23.1 Attention of Bidders is called to Act 150, Acts of Arkansas 1965, concerning the licensing of contractors to do business in Arkansas.
- 23.2 It is conclusively presumed that Bidders have familiarized themselves with Arkansas laws which may be applied to a Contract for the Work proposed herein as the aforementioned Acts are not exclusive. It is further conclusively presumed that Bidders have familiarized themselves with Federal and local laws, ordinances and regulations pertaining to the Work proposed herein.
- 23.3 All applicable laws, ordinances and the rules and regulations of all authorities having jurisdiction over construction of the Project shall apply to the Contract throughout.
- 23.4 This Agreement shall be governed by the laws of the State of Arkansas and shall bind the Parties, their partners, heirs, successors, administrators and assigns.
- 23.5 Indemnification: The Contractor shall indemnify, defend, and hold harmless Owner, the agents, officers, employees, and representatives of Owner (hereinafter "Indemnified Parties") against all liability and loss including reasonable attorney's fees and expenses to the extent resulting from the negligence or willful misconduct in connection with the Project by the Contractor, any subcontractor, or the agents, employees, or representatives of the Contractor or any subcontractor, including any injury (including death) sustained by or damage to the property of any person; provided however, that the Contractor shall not be responsible for any injury (including death), damage, or loss (including reasonable attorney's fees and expenses) which is caused by the sole negligence of an Indemnified Party.
- 23.6 Remedies: Except as may be otherwise provided in the Agreement, all claims, counter-claims, disputes and other matters in question between Owner and the Contractor arising out of or relating to this Agreement or the breach thereof will be decided by arbitration if the parties mutually agree, or in Pulaski County Circuit Court, Arkansas. Each and every right and remedy of Owner and Contractor will be construed as cumulative and not exclusive of any right or remedy otherwise available at law or in equity.
- 23.7 Attorneys' Fees and Costs: If any action is filed for breach or enforcement of this Agreement, in addition to any damages to which the party may be entitled, the





prevailing party will be entitled to reasonable attorneys' fees and costs from the unsuccessful party.

- 23.8 Publicity: Contractor shall not issue a news release or article pertaining to this solicitation or any portion of the project, in any medium, at any time during the pendency of the solicitation or fulfillment of the terms of this Agreement without Owner's prior written approval. Contractor's failure to comply with this requirement may be cause for Owner's rejection of Contractor's Bid, or Owner's cancellation of this Agreement.
- 23.9 Confidentiality: Contractor and Owner shall be bound to confidentiality of any information that its employees may become aware of during the course of performance of contracted services. Consistent and/or uncorrected breaches of confidentiality may constitute grounds for cancellation of the Agreement.

## **28. CONE OF SILENCE**

- 28.1 All communication(s) pertaining to this solicitation shall be directed to **Cary Beth Lipscomb, P.E.**, or her designee. Little Rock Water Reclamation Authority has imposed an absolute prohibition against any communication or contact ("Cone of Silence") with any other Little Rock Water Reclamation Authority personnel, Little Rock Water Reclamation Authority consultant, or Little Rock Water Reclamation Commission member regarding this solicitation.
- 28.2 The prohibition begins with the publication of this solicitation document, remains in place through the Little Rock Water Reclamation Authority solicitation and award process, and ends only after Little Rock Water Reclamation Authority has executed a contract with the successful Bidder. The prohibition is suspended only when **Cary Beth Lipscomb, P.E.**, or her designee, initiates or consents to a meeting or communication to clarify the solicitation or for another solicitation-related purpose.
- 28.3 A violation of this policy may result in the disqualification of an offending Bidder's bid response.

## **29. DISCLOSURE OF BID INFORMATION**

- 29.1 The Owner will rely on a Freedom of Information Act (FOIA) exemption to withhold all information contained in any submitted bid document to the Owner until after Contract Execution. The Owner will also rely on an FOIA exemption to withhold the certified bid tabulation until after Contract Execution. After that time and pursuant to Arkansas statute, bid information will be available for public review upon FOIA request. All Bidders are hereby advised that any information that they may consider to be confidential or proprietary and would give a competitive advantage if disclosed, should be identified, along with a statement as to whether or not a claim of confidential or proprietary privilege is being asserted. If such information is later sought by a FOIA request, the Bidder will be allowed to justify its claim of privilege and the Owner will assess the validity of said claim in advance of any release.



**30. NOTIFICATION OF NONDISCRIMINATION**

- 30.1 All parties to this contract shall not discriminate on the basis of race, color, creed, sex, age, national origin, disability, marital status, sexual orientation, gender identity, genetic information, political opinions or affiliation, military status, or other status protected by applicable law.

**33. OSHA**

- 33.1 Successful bidder must comply with the requirements of Act 291 of 1993 concerning trenches or other excavations five (5) feet deep or more in accordance with OSHA standards.

**34. ENGINEER OF RECORD**

- 34.1 The Engineer for the Project is:

**Little Rock Water Reclamation Authority  
Attn: John Holloway, P.E.  
11 Clearwater Drive  
Little Rock, Arkansas 72204  
Telephone (501) 688-1416  
Fax (501) 688-1409**

**35. ISRAEL BOYCOTT NOTICE**

- 35.1 Pursuant to Arkansas Code Annotated 25-1-503, a public entity shall not enter into a contract valued at \$1,000 or greater with a company unless the contract includes a written certification that the person or company is not currently engaged in, and agrees for the duration of the contract not to engage in, a boycott of Israel.
- 35.2 Vendor's signature on the Bid Signature Page shall represent and warrant they do not boycott Israel and will not boycott Israel during the remaining aggregate term of the contract.





## SECTION 00410

### BID FORM

Date: \_\_\_\_\_

PROPOSAL of \_\_\_\_\_,  
(hereinafter called "Bidder"), organized and existing under the laws of the State of \_\_\_\_\_,  
Doing business as \* \_\_\_\_\_.

\*Insert "a Corporation", "a Partnership", or "an Individual", as applicable.

To the **LITTLE ROCK WATER RECLAMATION COMMISSION** by and through the **LITTLE ROCK WATER RECLAMATION AUTHORITY, LITTLE ROCK, ARKANSAS**,  
(hereinafter called "Owner"):

In compliance with your Advertisement for Bids, Bidder hereby proposes to perform all Work for the construction of **Fourche Creek Water Reclamation Facility Industrial Equalization Basin Rehabilitation** in strict accordance with the Contract Documents, within the time set forth therein, and at the prices stated below.

The Contractor's Act of Assurance Form must be included in the bid proposal. The DBE/MBE/WBE Compliance Evaluation Forms must be supplied after the Low Bidder is confirmed.

By submission of this Bid, each Bidder certifies, and in the case of a joint Bid, each party thereto certifies as to its own organization, that this Bid has been arrived at independently, without consultation, communication, or agreement as to any matter relating to this Bid with any other Bidder or with any competitor.

Bidder hereby agrees to commence Work under this Contract on or before a date to be specified in the Notice to Proceed and to fully complete the Project within 180 consecutive calendar days thereafter. Bidder further agrees to pay as liquidated damages, the sum of \$1,000.00 per day for each consecutive calendar day past Substantial Completion, then \$500.00 per day for each consecutive calendar day past Final Completion (30 days after Substantial Completion) thereafter as provided in the Supplemental General Conditions.

Bidder accepts all of the terms and conditions of the Information for Bidders, including without limitation those dealing with the disposition of Bid Security. This Bid will remain open for sixty (60) days after the day of Bid Opening. Bidder will sign the Agreement required by these Contract Documents within ten (10) days after the date of Owner's Notice of Award.



In submission of this Bid, Bidder represents, as more fully set forth in the Agreement, that Bidder has examined all Contract Documents (including but not limited to Advertisement, Information for Bidders) and the following ADDENDA: (Insert Number & Date of issue for each Addendum):

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Failure to list all necessary Addenda issued by the Owner or Engineer could mean the Bid submitted by the Bidder may be deemed unresponsive and not read publicly.

In submission of the Bid, Bidder represents, that they have examined the site and locality where the Work is to be performed, the legal requirements (Federal, State and Local Laws, Ordinances, Rules and Regulations) and the conditions affecting cost, progress or performance of the Work and has made such independent investigations as Bidder deems necessary.

In submission of the Bid, Bidder represents, that this Bid is genuine and not made in the interest of or on behalf of any undisclosed person, firm or corporation and is not submitted in conformity with any agreement or rules of any group, association, organization or corporation. The Bidder represents that they have not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid. The Bidder represents that they have not solicited or induced any person, firm or corporation to refrain from bidding and have not sought by collusion to obtain for themselves any advantage over any other Bidder or over the Owner.

All terms used in the Bid are defined and have the meanings assigned to them in the General Conditions and Supplemental General Conditions of these Contract Documents.

Attached to this Bid Form is the required Bid Security in the form of a Bid Bond or Certified Check in the amount of five (5) percent of the Total Bid Amount.

Bidder hereby agrees to perform all the Work described in the Specifications, called for in the Contract Documents, and shown on the Drawings for the following Prices:



**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQUALIZATION  
BASIN REHABILITATION AND MODIFICATIONS**

**BID FORM**

Item No.	Bid Item Description	Unit	Quantity	Item Unit Cost	Total Item Cost
(1)	FCWRF Industrial Equalization Basin Rehabilitation and Modifications	LS	1	\$	\$
(2)	Electrical improvements	LS	1	\$	\$
(3)	Mobilization (5%)	LS	1	\$	\$
<b>TOTAL BID:</b>	<b>\$</b>				

The above-stated Total Bid shall include all labor, materials, equipment, overhead, profit, insurance, taxes, and incidentals to cover the cost of the finished work of the various kinds called for to complete the Project in a manner in full accordance with the Specifications and Contract Documents; so as to be fully acceptable to the Owner.



Respectfully Submitted,

Bidder: \_\_\_\_\_

Signature: \_\_\_\_\_

Printed Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Telephone Number: \_\_\_\_\_

Fax Number: \_\_\_\_\_

Arkansas Contractor's License Number: \_\_\_\_\_

Seal (If Bidder is a Corporation)



## SECTION 00430

### BID BOND

KNOW ALL MEN BY THESE PRESENTS, that we, the undersigned,

\_\_\_\_\_,  
as Principal, and

\_\_\_\_\_  
as Surety, are hereby held

and firmly bound unto the **Little Rock Water Reclamation Commission** acting by and through the **Little Rock Water Reclamation Authority, Little Rock, Arkansas** as Owner in the penal sum of five (5) percent of the Principal's Total Bid for the payment of which, well and truly to be made, we hereby jointly and severally bind ourselves, successors and assigns.

Signed, this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.

The Condition of the above obligation is such that whereas the Principal has submitted to the **Little Rock Water Reclamation Commission** acting by and through the **Little Rock Water Reclamation Authority, Little Rock, Arkansas** a certain Bid, attached hereto and hereby made a part hereof to enter into a Contract in writing, for the construction of the:

### **FOURCHE CREEK WRF FOG RECEIVING STATION PROJECT**

NOW THEREFORE,

- (a) If said Bid shall be rejected, or
- (b) If said Bid shall be accepted and the Principal shall execute and deliver a contract in the Form of Contract attachment hereto (properly completed in accordance with said Bid) and shall furnish a Bond for faithful performance of said contract, and for the payment of all persons performing labor or furnishing materials in connection therewith, and shall in all other respects perform the agreement created by the acceptance of said Bid, then this obligation shall be void, otherwise the same shall remain in force and effect; it being expressly understood and agreed that the liability of the Surety for any and all claims hereunder shall, in no event, exceed the penal amount of this obligation as herein stated.

The Surety, for value received, hereby stipulates and agrees that the obligations of said Surety and its Bond shall be in no way impaired or affected by any extension of the time within which the Owner may accept such Bid; and said Surety does hereby waive notice of any such extension.





IN WITNESS WHEREOF, the Principal and the Surety have hereunto set their hands and seals, and such of them as are corporations have caused their corporate seals to be hereto affixed and these presents to be signed by their proper officers, the day and year first set forth above.

Signed this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_.

Principal:

\_\_\_\_\_

Signature: \_\_\_\_\_

Printed Name & Title:

\_\_\_\_\_

Surety\*:

\_\_\_\_\_

Signature: \_\_\_\_\_

Printed Name & Title:

\_\_\_\_\_

\*Surety must attach valid Power-of-Attorney

Important - Surety companies executing Bonds must appear on the Treasury Department's most current list (Circular 570 as amended) to transact business in the State of Arkansas.



SECTION 00434

STATEMENT OF BIDDER'S SUBCONTRACTORS

The undersigned **BIDDER** proposes and agrees, if this **BID** is accepted, to use the following proposed subcontractors on this **Work**:

NAME	BUSINESS ADDRESS	WORK TO BE PERFORMED
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
6. _____	_____	_____

Date: \_\_\_\_\_

Signed: \_\_\_\_\_

END OF SECTION







DOCUMENT 00510

NOTICE OF AWARD

Date: \_\_\_\_\_

To: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Project Description: **Fourche Creek WRF Industrial EQ Basin Rehab**  
**Little Rock Water Reclamation Authority**  
**Little Rock, Arkansas**  
**Owner's Project Number: 7190700**

You are notified that your Bid dated \_\_\_\_\_, for the above Project has been accepted. You are the apparent successful Bidder and have been awarded a contract for Fourche Creek Water Reclamation Facility Industrial EQ Basin Rehab.

The Contract Price of your Contract is \_\_\_\_\_  
\_\_\_\_\_

Three (3) copies of the proposed Contract Documents (except Drawings) accompany this Notice of Award. Three (3) sets of the Drawings will be delivered separately or otherwise made available to you immediately.

You must comply with the following conditions precedent within ten (10) days of the date of this Notice of Award, that is by \_\_\_\_\_, 2021.

1. You must deliver to the Owner five (5) fully-executed counterparts of the Agreement.
2. You must deliver with the executed Agreement five (5) fully-executed copies of Performance and Payment Bonds.
3. You must deliver with the executed Agreement five (5) fully-executed copies of Certificate of Liability Insurance listing, LRWRA, Engineer, and ANRC as additional insured.

Failure to comply with these conditions within the time specified will entitle Owner to consider your Bid abandoned, to annul this Notice of Award and to declare your Bid Security forfeited.

Within ten (10) days after you comply with those conditions, Owner will return to you one fully-signed counterpart of the Agreement with the Contract Documents attached.



Dated this \_\_\_\_\_ day of \_\_\_\_\_, 2021.

Owner:

Little Rock Water Reclamation Commission

By and Through Little Rock Water Reclamation Authority

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_ John Holloway \_\_\_\_\_

Title: \_\_\_\_\_ Director of Engineering \_\_\_\_\_



## DOCUMENT 00520

### AGREEMENT

This Agreement, made this \_\_\_\_\_ day of \_\_\_\_\_, 2020, by and between **Little Rock Water Reclamation Commission by and through the Little Rock Water Reclamation Authority, Little Rock, Arkansas**, hereinafter called "Owner" and \_\_\_\_\_ doing business as (an individual,) (a partnership,) or (a Corporation,) hereinafter called "Contractor",

WITNESSETH: That for and in consideration of the payments and agreements herein after mentioned:

1. The Contractor will commence and complete the construction of: **Fourche Creek Water Reclamation Facility Industrial EQ Basin Rehabilitation**, for the price given in the Bid Form.
2. The Contractor will furnish all of the materials, supplies, tools, equipment, labor and other services necessary for the construction and completion of the Project described herein.
3. The Contractor will commence the work required by the Contract Documents within ten (10) calendar days after the date of the Notice to Proceed and will complete the same within 180 calendar days unless the period for completion is extended otherwise by the Contract Documents. The Contractor further agrees to pay as liquidated damages, the sum of \$1000 per day for each consecutive calendar day past Substantial Completion, then \$500 per day for each consecutive calendar day past Final Completion (30 days after Substantial Completion) as provided in Section 46 of the Supplemental General Conditions.
4. The Contractor agrees to perform all of the Work described in the Contract Documents and comply with the terms therein for the sum of:  
  
\_\_\_\_\_ Dollars (\$\_\_\_\_\_)
5. The term "Contract Documents" means and includes the Advertisement for Bids, Information for Bidders, Davis-Bacon Wage Determination(s), Bid Form, Bidder's Statement of Subcontractors, Statement of Bidder's Qualifications, Bid Bond, Agreement, General Conditions, Supplemental General Conditions, Payment Bond, Performance Bond, Warranty Bond, Notice of Award, Notice to Proceed, Contractor's Act of Assurance, DBE/MBE/WBE Certification and EPA Forms 6100-2, -3, and -4, Insurance, Certificate of Owner's Attorney, ANRC Approval of Contract, Change Orders, Drawings, Specifications and Addenda.



6. The Owner will pay to the Contractor in the manner and at such times as set forth in the Supplemental General Conditions such amounts as required by the Contract Documents.
7. This Agreement shall be binding upon all parties hereto and their respective heirs, executors, administrators, successors, and assigns.

IN WITNESS WHEREOF, the parties hereto have executed, or caused to be executed by their duly authorized official, this Agreement in five copies, each of which shall be deemed an original on the date first above written.

**OWNER:**

Little Rock Water Reclamation Commission  
By and Through  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

\_\_\_\_\_  
(Signature)  
Greg Ramon, Chief Executive Officer

**CONTRACTOR:**

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Print Name and Title)

\*ATTEST:

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Print Name and Title)





Address \_\_\_\_\_  
\_\_\_\_\_

Corporate Seal:

Employee Identification No. \_\_\_\_\_

Contractor License No. \_\_\_\_\_

\* If Contractor is a Corporation, the Secretary of the Corporation should Attest. Attach evidence of authority to sign





DOCUMENT 00550

**NOTICE TO PROCEED**

To: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Date: \_\_\_\_\_

Project Description: **Fourche Creek WRF Industrial EQ Basin Rehab**  
**Little Rock Water Reclamation Authority**  
**Little Rock, Arkansas**  
**Owner's Project Number: 7190700**

You are hereby notified that the Contract Time under the above Contract will commence to run on \_\_\_\_\_, 20\_\_\_. By that date, you are to start performing your obligations under the Contract Documents. In accordance with Article 3 of the Agreement, the date of Final Completion is \_\_\_\_\_, 20\_\_\_.

Before you start any Work at the site, Paragraph 2.7 of the General Conditions provides that you must deliver to the Owner Certificates of Insurance which you are required to purchase and maintain in accordance with the Contract Documents.

Dated this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_.

Owner:  
Little Rock Water Reclamation Commission  
By and Through Little Rock Water Reclamation Authority

By: \_\_\_\_\_  
(Signature)

Title: \_\_\_\_\_

**Acceptance of Notice**

Receipt of the above Notice to Proceed is hereby acknowledged:

Dated this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_.

By: \_\_\_\_\_

Title: \_\_\_\_\_





DOCUMENT 00610

PERFORMANCE BOND

Bond Number: \_\_\_\_\_

KNOW ALL MEN BY THESE PRESENTS, That

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Address of Contractor)

a \* \_\_\_\_\_, hereinafter called "Principal", and  
(\*Corporation, Partnership, or Individual)

\_\_\_\_\_  
(Name of Surety)

\_\_\_\_\_  
(Address of Surety)

hereinafter called "Surety", are held and firmly bound unto

Little Rock Water Reclamation Commission  
acting by and through the  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

hereinafter called "Owner", in the total aggregate penal sum of

\_\_\_\_\_ Dollars (\$ \_\_\_\_\_)  
in lawful money of the United States, for the payment of which sum well and truly to be  
made, we bind ourselves, our heirs, executors, administrators, successors, and assigns,  
jointly and severally, firmly by these Presents.

The condition of this obligation is such that whereas, the Principal entered into a certain  
Contract with the Owner, dated \_\_\_\_\_, \_\_\_\_\_, a copy of which is  
hereto attached and made a part hereof for the construction of:

**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQ BASIN  
REHABILITATION**

NOW, THEREFORE, if the Principal shall well, truly and faithfully perform its duties, all  
the undertakings, covenants, terms, conditions, and agreements of said contract during



the original term thereof, and any extensions thereof which may be granted by the OWNER with or without notice to the Surety and during the one year guaranty period and if the Principal shall satisfy all claims and demands incurred under such contract, and shall fully indemnify and save harmless the OWNER from all costs and damages which it may suffer by reason of failure to do so, and shall reimburse and repay the OWNER all outlay and expense which the OWNER may incur in making good any default, then this obligation shall be void, otherwise to remain in full force and effect.

PROVIDED, FURTHER, that the said Surety, for value received hereby stipulates and agrees that no change, extension of time, alteration or addition to the terms of the contract or to WORK to be performed thereunder or the SPECIFICATIONS accompanying same shall in any way affect its obligation on this BOND, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the contract or to the WORK or to the SPECIFICATIONS.

PROVIDED, FURTHER, that it is expressly agreed that the Bond shall be deemed amended automatically and immediately, without formal and separate amendments hereto, upon amendment to the Contract not increasing the contract price more than 20 percent, so as to bind the Principal and the Surety to the full and faithful performance of the Contract as so amended. The term "Amendment", wherever used in this Bond, and whether referring to this Bond, the Contract or the Loan Documents shall include any alteration, addition, extension, or modification of any character whatsoever.

PROVIDED, FURTHER, that no final settlement between the OWNER and the PRINCIPAL shall abridge the right of the other beneficiary hereunder, whose claim may be unsatisfied. The Owner is the only beneficiary hereunder.



IN WITNESS WHEREOF, this instrument is executed in five (5) counterparts, each one of which shall be deemed an original, this the \_\_\_\_ day of \_\_\_\_\_, 2020.

**PRINCIPAL:**

\_\_\_\_\_  
(Company)

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
(Surety)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

By: \_\_\_\_\_  
(Signature Attorney-in-Fact)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**SEAL**

**ATTEST:**

By: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**NOTE:** Date of BOND must not be prior to date of Contract. If CONTRACTOR is a Partnership, all Partners must execute this BOND.

**IMPORTANT:** Surety companies executing BONDS must appear on the Treasury Department's most current list (Circular 570 as amended) and be authorized to transact business in the State of Arkansas.







**SECTION 00612**

**WARRANTY BOND**

Bond Number: \_\_\_\_\_

KNOW ALL MEN BY THESE PRESENTS, That

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Address of Contractor)

a \* \_\_\_\_\_, hereinafter called "Principal", and  
(\*Corporation, Partnership, or Individual)

\_\_\_\_\_  
(Name of Surety)

\_\_\_\_\_  
(Address of Surety)

hereinafter called "Surety", are hereby jointly and severally held and firmly bound unto

Little Rock Water Reclamation Commission  
acting by and through the  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

as Oblige ("Owner"), for the payment of the total aggregate penal sum of  
\_\_\_\_\_ Dollars (\$\_\_\_\_\_) )  
subject to the terms and conditions provided herein.

WHEREAS, Principal executed and entered into that certain Agreement with Owner for:

**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL  
EQUALIZATION BASIN REHABILITATION**

dated \_\_\_\_\_, 20\_\_\_\_ (the "Contract"), the provisions of which are  
incorporated herein by reference, and unless otherwise defined herein all defined terms  
used or referred to herein shall have the meaning ascribed thereto in the Contract. In  
addition to other obligations and liabilities, the Contract required Principal to perform the



work for the Project and to furnish this Bond to Owner in compliance with Section 22 of the General Conditions and the RLF Supplemental General Conditions.

NOW THEREFORE, the obligations of Principal and Surety herein shall remain in full force and effect as provided herein, subject to becoming null and void upon the occurrence of either or both of the conditions that (a) Principal shall fully perform and satisfy all obligations and liabilities of Principal under the warranty and guarantee provisions of Sections 22.1 and 22.2 of the General Conditions, as modified or supplemented by the RLF Supplemental General Conditions or any other applicable Contract Documents, at any time within one year after the date of Final Acceptance or such longer period of time as may be prescribed therein (the "Warranty Period"), all of which includes without limitation either correcting the defective Work, or removing and replacing it with nondefective Work, or paying all direct, indirect or consequential costs of such correction or removal and replacement, all as provided therein, or (b) Owner shall fail to institute a lawsuit, action or other proceeding under this Bond before the expiration of three (3) months following the end of the Warranty Period.

FURTHER PROVIDED, that (a) any changes, modifications, amendments, alterations or supplementations in or to the Contract, and Contract Documents or the Work, or the giving by Owner of any extension of time for the performance of the Contract, or any other forbearance on the part of either Owner or Principal to the other, shall not in any way release the Principal or Surety, or either of them, from their liability hereunder, notice to the Surety of any of the foregoing being hereby waived, (b) in no event shall the aggregate liability of Surety exceed the amount set out herein, and (c) the rights and obligations hereof shall be binding upon and shall inure to the benefit of Principal, Surety, Owner and their respective heirs, legal representatives, partners, privies, successors and assigns, provided that nothing herein shall authorize the assignment of any such rights and obligations except upon compliance with Section 23 of the General Conditions.

Date of project final completion is \_\_\_\_\_. The bond shall be effective for a period of one year.



IN WITNESS WHEREOF, this instrument is executed in five (5) counterparts, each one of which shall be deemed original, this the \_\_\_\_\_ day of \_\_\_\_\_ 20 \_\_\_\_.

**PRINCIPAL:**

\_\_\_\_\_  
(Company)

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

**SURETY:**

\_\_\_\_\_  
(Surety)

Address: \_\_\_\_\_

\_\_\_\_\_

Phone No. \_\_\_\_\_

By: \_\_\_\_\_  
(Signature Attorney-in-Fact)

Address: \_\_\_\_\_

\_\_\_\_\_

Phone No. \_\_\_\_\_

**SEAL**

**ATTEST:**

By: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

**IMPORTANT:** Surety Companies executing BONDS must appear on the Treasury Department's most current list (Circular 570 as amended) and be in accordance with Section 16 of the RLF Supplemental General Conditions and be authorized to transact business in the State of Arkansas.





DOCUMENT 00615

**PAYMENT BOND**

Bond Number: \_\_\_\_\_

KNOW ALL MEN BY THESE PRESENTS, That

\_\_\_\_\_  
(Name of Contractor)

\_\_\_\_\_  
(Address of Contractor)

a \* \_\_\_\_\_, hereinafter called "Principal", and  
(\*Corporation, Partnership, or Individual)

\_\_\_\_\_  
(Name of Surety)

\_\_\_\_\_  
(Address of Surety)

hereinafter called "Surety", are held and firmly bound unto

Little Rock Water Reclamation Commission  
acting by and through the  
Little Rock Water Reclamation Authority  
11 Clearwater Drive  
Little Rock, Arkansas 72204

hereinafter called "Owner" and unto all persons, firms and corporations who or which may furnish labor, or who furnish materials to perform as described under the contract and to their successors and assigns in the total aggregate penal sum of \_\_\_\_\_ Dollars (\$\_\_\_\_\_) in lawful money of the United States, for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors, and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION is such that whereas, the Principal entered into a certain Contract with the Owner, dated \_\_\_\_\_, \_\_\_\_\_ a copy of which is hereto attached and made a part hereof for the construction of:

**FOURCHE CREEK WATER RECLAMATION FACILITY INDUSTRIAL EQUALIZATION  
BASIN REHABILITATION**



Now, therefore, if the Principal shall promptly make payment to all persons, firms, and corporations furnishing materials for or performing labor in the prosecution of the Work provided for in such contract, and any authorized extensions or modification thereof, including all amounts due for materials, lubricants, oil, gasoline, coal and coke, repairs on machinery, equipment and tools, consumed or used in connection with the construction of such Work, and for all labor cost incurred in such Work including that by a Subcontractor, and to any mechanic or materialman lienholder whether it acquires its lien by operation of State or Federal law; then this obligation shall be void, otherwise to remain in full force and effect.

PROVIDED, that beneficiaries or claimants hereunder shall be limited to the Subcontractors, and persons, firms and corporations having a direct contract with the Principal or its Subcontractors.

PROVIDED, FURTHER, that the said Surety for value received hereby stipulates and agrees that no change, extension of time, alteration or addition to the terms of the contract or to the Work to be performed thereunder or the Specifications accompanying the same shall in any way affect its obligation on this Bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of this contract or to the Work or to the Specifications.

PROVIDED, FURTHER, that no suit or action shall be commenced hereunder by any claimant: (a) Unless claimant, other than one having a direct contract with the Principal, shall have given written notice to any two of the following: The Principal, the Owner or the Surety above named within ninety (90) days after such claimant did or performed the last of the work or labor, or furnished the last of the materials for which said claim is made, stating with substantial accuracy the amount claimed and the name of the party to whom the materials were furnished, or for whom the work or labor was done or performed. Such notice shall be served by mailing the same by registered mail or certified mail, postage prepaid, in an envelope addressed to the Principal, Surety, at any place where an office is regularly maintained for the transaction of business, or served in any manner in which legal process may be served in the State in which the aforesaid project is located, save that such service need not be made by a public officer. (b) After the expiration of one (1) year following the date of which Principal ceased work on said Contract, is being understood, however, that if any limitation embodied in the Bond is prohibited by any law controlling the construction hereof, such limitation shall be deemed to be amended so as to be equal to the minimum period of limitation permitted by such law.

PROVIDED, FURTHER, that it is expressly agreed that this Bond shall be deemed amended automatically and immediately, without formal and separate amendments hereto, upon amendment to the Contract not increasing the contract price more than 20 percent, so as to bind the Principal and the Surety to the full and faithful performance of the Contract as so amended. The term "Amendment", whenever used in this Bond and whether referring to this Bond, the contract or the loan Documents shall include any alteration, addition, extension or modification of any character whatsoever.

PROVIDED, FURTHER, that no final settlement between the Owner and the Contractor



shall abridge the right of any beneficiary hereunder, whose claim may be unsatisfied.

IN WITNESS WHEREOF, this instrument is executed in five (5) counterparts, each one of which shall be deemed an original, this the \_\_\_\_\_ day of \_\_\_\_\_, 2020.

**PRINCIPAL:**

\_\_\_\_\_  
(Company)

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
(Surety)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

By: \_\_\_\_\_  
(Signature Attorney-in-Fact)

Address: \_\_\_\_\_  
\_\_\_\_\_

Phone No. \_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
(Signature)

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**SEAL**

**ATTEST:**

By: \_\_\_\_\_

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

**NOTE:** Date of BOND must not be prior to date of Contract. If CONTRACTOR is a Partnership, all Partners must execute this BOND.

**IMPORTANT:** Surety Companies executing BONDS must appear on the Treasury Department's most current list (Circular 570 as amended) and be in accordance with Section 16 of the RLF Supplemental General Conditions and be authorized to transact business in the State of Arkansas.







## SECTION 01000

### BASIC REQUIREMENTS

#### PART 1 - GENERAL

##### 1.1 DESCRIPTION AND SCOPE OF WORK

- A. The work included in this Contract consists of the furnishing of all tools, labor, equipment, materials, and supplies necessary to fully construct to the satisfaction of the Engineer and Owner the FCWRF FOG Receiving Station Project together with all incidental and ancillary work as shown on the Drawings. Installation is to be complete and inclusive of pipe, fittings, service connections, excavation, trenching, bedding material, backfill material, concrete, manholes, connection to existing lines(s), acceptance testing, traffic control, trench safety, and restoration of streets and property.
- B. Whenever in these Documents the word "Owner" appears, it shall be understood to mean the Little Rock Water Reclamation Commission acting by and through Little Rock Water Reclamation Authority.
- C. Work or material not specifically mentioned in the Specifications, but designated on the Drawings, or forming an essential part of the Work mentioned or designated, shall be furnished and installed by the Contractor as though specifically mentioned.
- D. Construction of the work shall be by one General Contractor, utilizing Subcontractors for those specialties and portions of the Work that the General Contractor chooses to subcontract. All Subcontractors are subject to approval by the Engineer and Owner in accordance with applicable sections of the General Conditions and Supplemental General Conditions to these Specifications. The General Contractor shall maintain a responsible representative on-site whenever his subcontractors are on-site and engaged in the Work.
- E. The Drawings show the proposed location and details of construction work in this Contract. All work shall be performed by the Contractor in a thorough and workmanlike manner, in full accordance with the Drawings and Specifications by skilled and competent workmen well experienced in such construction methods and techniques.
- F. Any reference in these Specifications to an engineering standard (such as ASTM or AWWA) shall be to the latest version or edition as of the Bid Date.
- G. The Contractor shall not be permitted to sublet, sell or assign this contract or sublet any of the work to be performed hereunder without the written consent of the Owner (by and through the Engineer) and any such assignment or subletting of any such work without said consent shall be null and void and without force and effect. The Owner shall have the right to assign in whole or in part its rights hereunder.
- H. **The Little Rock Water Reclamation Authority "Standard Specifications for Design and Construction of Sewer Lines, Latest Edition" and the Little Rock Water Reclamation Authority Standard Details included in the Appendix, shall be a fundamental component of these Contract Documents and all provisions of the document and details shall be followed, unless otherwise shown on the Drawings or modified in the Specifications, or as directed by the Engineer.**



## COPIES OF DRAWINGS AND SPECIFICATIONS

- A. The Contractor will be provided sufficient copies of the Drawings and Specifications at no cost to the Contractor.

### 1.3 PERMIT(S)

- A. The Contractor shall be responsible for securing any required permit for the construction of the Project. Permits that may be required include but are not limited to City of Little Rock, Arkansas Highway and Transportation Department, and Arkansas Department of Environmental Quality Storm Water.
- B. A copy of all executed permits obtained for the Work in this project shall be submitted to the Engineer within five (5) days of Contractor receiving approval. Any permit process requiring involvement with the Owner shall be submitted to the Engineer for processing. The Owner shall have 14 days to process and execute any permitting related requests.

### 1.4 WRITTEN NOTICES

- A. Written notices, when required by the Contract Documents or for purposes of project administration, shall be mailed by Certified Mail, return receipt requested, as follows:
  - 1. If to the Owner: Little Rock Water Reclamation Authority  
Attn: Cary Beth Lipscomb, P.E.  
11 Clearwater Drive  
Little Rock, Arkansas 72204
  - 2. If to the Contractor: At the address as stated in the Agreement.

### 1.5 EXISTING UTILITIES AND SUBSURFACE STRUCTURES

- A. The construction work encompassed in this Contract will require excavation and related activity in close proximity to existing buried utility lines and subsurface structures (and some aerial facilities). The approximate location of such utilities and structures is shown on the Drawings, but all such utilities, structures, and individual service lines are not shown. The Contractor is to be aware of the potential for such buried utility lines and structures conflicting with his intended construction efforts, and use proper precautionary measures to locate, verify, and protect such buried lines and structures so as to avoid damage.
- B. Information and data reflected on the Drawings with respect to underground facilities at or contiguous to the site is based upon information and data furnished to Owner and Engineer by owners of such underground facilities or others, and Owner and Engineer do not assume responsibility for the accuracy or completeness thereof. Provisions concerning responsibilities for the adequacy of data furnished to the Contractor on subsurface conditions, underground facilities and other physical conditions, and possible changes in the Contract Documents due to differing conditions appear in the Supplemental General Conditions and/or General Conditions.
- C. The Contractor shall contact the owners of the various existing buried utility lines (or aerial facilities) and structures as impacted by his construction activities, and obtain their assistance in identifying, locating, and marking affected facilities prior to beginning any excavation which might endanger the existing facilities. The Contractor will bear all costs in connection with the location, marking, temporary protection, or support of such utility facilities. If such utilities are damaged or impaired due to the actions or omissions of the Contractor, then the Contractor is responsible for the cost of repairs or replacement of the affected or damaged utility lines.



- D. The Contractor shall make necessary exploratory excavations to determine the location of underground structures such as pipes, drains, conduits, and other structures.
- E. The Contractor shall provide adequate protection and support for all surface and subsurface structures or other facilities encountered during the progress of the work.
- F. The Contractor must comply with the ARKANSAS ONE-CALL (811) system, and alert the Utility Systems accordingly.
- G. The Contractor shall be responsible for any damage to the Owner's equipment and facilities resulting from Contractor's negligence. Contractor shall make immediate repairs to damages at his expense. In the event service has been disrupted, immediate repair operations shall be continuous and around the clock until complete, if necessary.
- H. If any utility facility or structure is damaged during the progress of the work, the Contractor shall immediately notify the appropriate owner. Repairs shall not be made by the Contractor without the prior approval of the utility facility or structure owner. The Contractor shall provide available assistance to the utility involved in making repairs under emergency conditions.

#### 1.6 SAFETY REQUIREMENTS

- A. Contractor shall be totally responsible for all necessary safety measures and precautions as stipulated in the General Conditions to these Specifications, and in compliance with the Occupational Safety and Health Administration's (OSHA) requirements applicable to the work of the various kinds as called for under this Contract. Particular attention is called to the Appendix of these Specifications pertinent to Excavation and Trench Safety.
- B. The Contractor shall be totally responsible for providing and maintaining any necessary and required barricades, safety fences, signs, markers, shoring, bracing, etc. to provide for the protection of workmen and the Owner's personnel during the duration of the Work under this Contract.

#### 1.7 ENVIRONMENTAL ASPECTS

- A. The work shall be planned and executed in full compliance with the requirements of the Federal Environmental Protection Agency (EPA), the Arkansas Department of Environmental Quality (ADEQ), and all local authorities.
- B. Dust Control: During periods of dry, dusty conditions at the construction site, the work shall be planned and executed so as to minimize dust problems. Contractor shall provide for watering of the construction site, haul roads, and any other disturbed areas to prevent excessive dust problems within the vicinity. Failure of the Contractor to provide adequate dust control shall be just cause for stopping all other work until the areas causing the dust have been watered and the dust controlled. Water for such dust control shall be provided by the Contractor.
- C. Noise Control: The work shall be planned and executed to minimize noise on the construction site. All applicable measures for noise control as required by OSHA standards shall be used.
- D. Burning: Logs, limbs, tops, stumps, roots and other debris may be burned in approved designated areas with the approval of all applicable local authorities, including the City of Little Rock Fire Department, and City of Little Rock ordinances. All state and local laws pertaining to controlled burning must be followed. No burning shall occur in a maintained landscape. No scrap paper, cans, scrap pipe, etc. may be burned. If the Contractor is not allowed to burn the above-mentioned items, then all debris from clearing operations



shall be hauled off site for disposal. Contractor will be responsible for disposal of all such debris in an approved disposal area.

#### 1.8 STORM WATER PERMIT, POLLUTION PREVENTION PLAN AND SILTATION CONTROL

- A. The work shall be so planned and executed so as to prevent siltation of area streams, ditches, swales, and drainages. Barriers, silt fences and filters shall be constructed as necessary by the Contractor to intercept and impede silt or debris laden runoff from the construction site and prevent excessive quantities of silt and debris from reaching area streams and drainages.
- B. **Contractor shall complete for the Owner, all Storm Water Permit forms (if required) as required by the Arkansas Department of Environmental Quality (ADEQ). The Contractor shall submit all forms to the Engineer for Owner signature and forwarding to ADEQ. The Contractor shall be responsible for any and all fees, notices, notice of intent, notice of termination, disclosure statements, storm water pollution prevention plan, etc. associated with obtaining the Storm Water Permit. Contractor shall prepare the storm water pollution prevention plan (if required) and send to the Engineer for Owner signature and forwarding to ADEQ. Refer to specification Section 01573 Temporary Erosion and Sediment Control.**
- C. Contractor shall be responsible for the cost of all claims, losses, fines, penalties, or damages charged to Owner due to Contractor's failure to comply with the requirements of the Storm Water Permit. If requested, Contractor shall provide copies of the storm water permit, notices, and storm water pollution prevention plan to the Owner.
- D. Contractor shall follow all requirements of the Storm Water Pollution Prevention Plan and Storm Water Permit. The Owner reserves the right to stop all work if the Storm Water Pollution Prevention Plan is not being properly implemented and followed and if the Storm Water Permit forms are not kept up to date by the Contractor.

#### 1.9 FLOW CONTROL AND BYPASS PUMPING

- A. When the flow of sewage in the sewer line section under construction is above the maximum for proper execution of the work, flows shall be reduced to an acceptable level through plugging, blocking and bypass pumping of the flows.
- B. When the sewage flow is blocked or plugged, sufficient precautions shall be taken to protect the public health and protect sewer lines from damage. No sewage shall be allowed to backup into any homes or building. No sewage shall overflow any manhole, cleanout, or any other sewer access. Users upstream of the replacement area shall be able to use all of their water and sewer utilities without interruption. During any time when an active sewer is plugged or blocked, the Contractor shall observe the conditions upstream of the plug and be prepared to immediately start bypass pumping if needed.
- C. When bypass pumping is required, the Contractor shall provide the necessary pumps, conduits, and other equipment to divert the flow of sewage around the section in which work is to be performed. The bypass system shall be of sufficient capacity to handle existing flow plus additional rainfall induced flow. An additional stand-by pump shall be on-site in case of a pump failure.
- D. The Contractor shall properly operate and maintain any active bypass system. Pumps and equipment shall be continuously monitored by an employee capable of starting, stopping, refueling, and maintaining the pumps during the entire period for which bypass pumping is necessary. If pumping is required on a 24-hour basis, engines shall be equipped in a manner to keep noise to a minimum and within local required levels.



- E. Any pump operated by the Contractor which pulls sewage or any type of material out of a manhole or sewer shall discharge this material into another manhole or appropriate container. Under no circumstances shall this material be discharged, stored, or deposited on the ground, street, road, or open environment.
- F. The Contractor shall take appropriate steps to ensure that all pumps, piping, and hoses that carry sewage are protected from traffic.
- G. The Contractor shall be responsible for having sufficient pumping capacity on site in case of an emergency, i.e. a broken water line. Under no circumstances shall groundwater, surface water, drinking water, or any other water source other than sewage be discharged into the sanitary sewer collection system.
- H. Temporarily plugging a sewer line shall be approved by the Engineer and Owner.
- I. If requested by the Owner or Engineer, Contractor shall submit details of bypass plan.
- J. Immediately contain raw sewage spills and overflows caused by construction work. Contractor shall adhere to Little Rock Water Reclamation Authority's SSO procedures regarding appropriate response, cleanup, disinfection, and notification. Contractor shall conduct SSO procedures, at the behest of Little Rock Water Reclamation Authority, or shall assist Little Rock Water Reclamation Authority crews with SSO procedures. The Contractor shall be responsible for any and all fines, fees, expenses, labor costs, material costs, or settlements with property owners. Contractor shall at no time attempt to address SSO's without Owner's assistance or without notification to the Engineer or the Engineer's Representative. Repetitive SSO events shall not be tolerated and Contractor may face legal and/or civil action suits for such cases.
- K. Contractor shall immediately report any sanitary sewer spills and overflows onto any surface to the Engineer or the Engineer's Representative. No surfaces or amounts are exempt. Provide completed Sanitary Sewer Overflow (SSO) event information to the Engineer or Engineer's Representative by the end of work day. Include the following information: date of incident, specific location, start and stop times, the duration, volume, description of cause, whether overflow went into a waterway, impact (or possible impact) to area or environment, contact information of property owner (if known), contact information of construction crew and Contractor's foreman, resolution of SSO incident, how future reoccurrences will be prevented, and any other information pertinent to the SSO event or as requested by the Engineer.
- L. At Engineer and/or Owner's request, Contractor shall post notices of SSO event any time there is a chance of public exposure, when a SSO occurs in close proximity to a waterway, is 10,000 gallons or greater, or if possibility of human contact. Do not remove posted notices while evidence of the SSO remains. The SSO notice shall be posted for the following durations: a) Post for 2 weeks for SSO up to 100,000 gallons; or b) Post for 30 days for SSO greater than 100,000 gallons. Engineer shall direct Contractor of further notification requirements, which shall occur no more than 24-hours after the event and may require the Contractor personally notifying Schools, Hospitals, Daycare Centers, Elder Care centers, and similar areas when a SSO has occurred within close proximity (500-feet) of any of such facilities.

#### 1.10 CONSTRUCTION CONTROL, LAYOUT, AND SCHEDULING

- A. All work shall be constructed in accordance with the lines and grades shown on the Drawings. Elevations of existing ground, structures, and appurtenances, and existing utilities are believed to be reasonably correct as shown but are not guaranteed to be absolute and therefore are presented only as an approximation. Any error or apparent discrepancy in the data shown or omissions of data required for accurately locating the



work shall be referred immediately to the Engineer for interpretation or correction.

- B. The Contractor is responsible for all construction layout and both horizontal and vertical control of construction operations at all construction sites. The Engineer will provide surveys to establish reference points and benchmarks which are in the Engineer's judgement necessary to enable the Contractor to proceed with the work. Contractor shall report to the Engineer when any reference point is lost or destroyed. The Contractor shall furnish necessary assistant(s) to serve as rodman/chainman. Such assistant(s) to be provided by the Contractor shall be at no additional cost to the Owner or the Engineer. Contractor will be responsible for all street, drainage, and pipeline grade control. Contractor will set all grade stakes, slope stakes, etc. as necessary for the proper control of construction effort; all in such manner as to complete the structures and facilities to such line and grade as established on the Drawings or as directed by the Engineer and Owner.
- C. The Contractor shall be responsible for resetting all property pins disturbed by construction activities. All survey work for replacing property markers shall be done by a Licensed Surveyor.
- D. The Contractor shall carefully preserve benchmarks, reference points and stakes and in case of willful or careless destruction, the Contractor shall be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.
- E. The Contractor shall prosecute the construction of said work with due diligence and at such a rate and in such manner as in the opinion of the Engineer and Owner is necessary for completion within a reasonable time. The Contractor shall not open up work to the prejudice of work already started and shall arrange its work and dispose of materials so as to insure the least possible interference and inconvenience to the land owners on or beside whose property the pipelines are being constructed or to the public where the pipelines lie in or near a public thoroughfare. Contractor shall employ such number of construction crews as are necessary to construct said project within the allotted time provided.

#### 1.11 NORMAL PROJECT WORKING HOURS

- A. Normal project working hours for this project are Monday through Friday between the hours of 7:00 am and 7:00 pm. Work shall not be permitted on Saturday, Sunday, or any of the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day, unless written permission is requested by the Contractor and approved by the Engineer and Owner at least 48 hours prior to work taking place. The Owner will require that a representative of the Owner be present or available for work which occurs outside of the normal project working hours. The Contractor shall compensate the Owner for salary costs and expenses incurred by the Owner as a result of the Contractor choosing to work outside the normal project working hours.
- B. The Contractor shall compensate the Owner for the salary costs and expenses incurred as a result of the Contractor choosing to work outside the normal project working hours as follows:
  - 1. Labor costs multiplied by 3 plus expenses such as lodging, mileage, materials, meals, etc.
- C. The Contractor may perform clean-up work outside of regular hours with the approval of the Engineer and Owner. Clean-up work shall be approved by the Engineer and Owner at least 48 hours prior to work taking place.





#### 1.12 APPLICATION FOR PAYMENT

- A. Refer to specifications in Division 00 for further information regarding Application for Payment and Payments to Contractor.
- B. At least ten days before each progress payment falls due (but not more often than once a month), the Contractor shall submit an itemized list of quantities to the Engineer utilizing Unit Prices and a schedule of values for Application for Payment. Contractor shall review quantities and stored materials with Engineer's Representative prior to submitting Application for Payment to the Engineer. The deadlines for all disbursements will be discussed at the preconstruction conference. Disbursement requests not received by the Engineer prior to the deadlines established in the preconstruction conference may not be processed and paid until the following month.
- C. The estimate shall show a detailed breakdown of the amount of work completed previously, amount of work completed this period, amount of work completed to date, the amount of retainage, and the quantity and value of materials and equipment currently stored on site that have not been incorporated into the work. Partial payment requests shall include a copy of the updated construction schedule.
- D. Pay Periods: Calendar Month.
- E. Contractor shall submit to the Engineer for review, a detailed schedule of construction progress indicating the sequence of work, time of starting and anticipated completion of each part, and any unusual or critical aspects of the construction scheduling. The schedule shall include provisions for maintenance of traffic. Schedule may be of graphic form indicating time elements for the various portions of work. Revise and resubmit schedule as required.
- F. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at or near the site, the partial payment estimate shall also be accompanied by such supporting data, satisfactory to the Engineer, as will establish the Owner's title to the material and equipment and protect the Owner's interest therein, including applicable insurance
- G. This project is federally funded through the State Revolving Loan Fund (RLF) and is being administered by the Arkansas Natural Resources Commission (ANRC). Disbursements from the State Revolving Loan Fund (RLF) Programs shall be made monthly based upon actual work performed and materials stored on site less retainage.
- H. Partial payment requests shall include a certification by the Contractor that it has complied with all labor standards. The Contractor shall provide the Engineer a letter with each pay request certifying wages, through payroll review and employee interviews, meet the Davis-Bacon Requirements of this contract. Copies of payroll documents and completed interviews will be forwarded to the Engineer, if requested.

#### 1.13 CONFERENCES, PUBLIC MEETINGS AND NOTICES

- A. The Engineer will schedule a preconstruction conference after Notice of Award. Project progress meetings may be held periodically.
- B. Contractor shall be available to attend public meetings at the Engineer and Owner's request.
- C. Contractor shall prepare and deliver notices necessary for the performance of the Work. Contractor shall coordinate the content of the notice with the Owner. Every reasonable



effort shall be made to distribute notices two (2) days prior to any Work, however, Owner will allow the Contractor to distribute notices up to a minimum of one day in advance of Work.

- D. Contractor may distribute notices up to a maximum of fourteen (14) days prior to Work. If conditions do not allow Work to be performed during this period, Contractor will redistribute notices. If redistribution of notices is required, Work may be performed within one (1) day of noticing. The Owner, Little Rock Fire Department, Little Rock Police Department, and Little Rock Information 311 shall be notified daily of any Work via email, fax, or other approved method.
- E. Contractor vehicles, equipment, and machinery shall have an identifying logo in a visible location. Any contractor employee working on-site shall wear an identification badge which shall include a photo, name, company, and role/title.

#### 1.14 QUALITY ASSURANCE

- A. Maintain quality control over suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of specified quality.
- B. Comply fully with manufacturer's instructions.
- C. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- D. The Contractor shall supervise and direct the Work. The Contractor shall be solely responsible for the means, methods, techniques, sequences and procedures of construction. The Contractor shall employ and maintain on the Work a qualified supervisor or superintendent who shall have been designated by the Contractor as the Contractor's representative at the site. The supervisor shall have full authority to act on behalf of the Contractor and all communications given to the supervisor shall be as binding as if given to the Contractor. The supervisor shall be present on the site at all times as required to perform adequate supervision and coordination of the Work. The Engineer and Owner shall have the right at all times to require the removal of any superintendent, foreman, or workman for performing inferior work.
- E. Should any work be performed by the Contractor without giving notice of plan of work and opportunity of inspection by the Engineer and Owner or his representative, the Engineer and/or Owner may require the Contractor to uncover such work at his own expense for examination by the Engineer. The cost of uncovering such work shall be the responsibility of the Contractor, whether or not the work is found acceptable. The work shall be subject to inspection by other appropriate AHTD, City, County, State, Federal or other governmental inspectors at all times.
- F. The methods, equipment, and appliances shall produce a satisfactory quality of work and shall be adequate to maintain the schedule of progress. The Contractor shall maintain all equipment in good repair to ensure efficient performance of the work required. The Engineer and Owner shall have the right to require the removal and/or replacement of any equipment which he deems incapable of satisfactory performance.

#### 1.15 MAINTENANCE OF TRAFFIC

- A. The Contractor shall maintain traffic and protect the public from all damage to persons and property in accordance with all applicable State, City, and County regulations. Contractor shall conduct his operations so as to maintain and protect access, for vehicle and pedestrian traffic, to and from all properties adjoining or adjacent to those streets





affected by his operations, and to subject the public to a minimum of delay and inconvenience.

- B. Suitable signs, barricades, danger lights, etc., shall be erected and the work outlined by adequate lighting at night in order to protect persons from injury and avoid property damage. The Contractor shall provide qualified flagmen to direct traffic while working upon a highway, street, or road over which traffic must pass.
- C. Traffic shall be detoured as required; however, no traffic shall be detoured without prior knowledge and approval of the traffic control agency having jurisdiction. Contractor shall notify the Engineer at least 24 hours in advance of the time he proposes to detour traffic. No street shall be completely blocked, nor blocked more than one-half at any time without specific authorization. Any pavement markings damaged during the Work shall be removed and replaced promptly by the Contractor.
- D. Traffic control shall be in accordance with City of Little Rock and/or the Arkansas Department of Transportation Standard Specifications, latest edition. Traffic control shall be in accordance with the agency having jurisdiction within the area of work.
- E. Closing streets with one access route shall not be acceptable or permitted. One traffic lane shall remain open at any given time. Excavated areas within the traffic lanes of highways, streets, roads, and pedestrian walkways shall be backfilled as soon as possible and the area reopened to traffic.
- F. The Contractor shall be responsible for making provisions for the safe and free passage of persons and vehicles by, over, or around the work while it is in progress. Such provisions or traffic control plans shall be satisfactory with the Engineer, Owner, State, County, and Local authority having jurisdiction within the area of work.
- G. The Contractor shall make the same provisions as described above for the passage of vehicular and pedestrian traffic between private property and public highways, streets, and roads that are satisfactory to the Engineer, Owner and private property owners involved.
- H. Contractor shall obtain street closing permits from State, County, City or Local authority having jurisdiction within the area of work. Copies of all permits shall be provided to Engineer.
- I. Contractor shall notify law enforcement agencies, fire departments, and other impacted agencies and personnel.
- J. Contractor shall submit a barricade plan to traffic control agency having jurisdiction and Engineer.

#### 1.16 USE OF COMPLETED PORTIONS

- A. The Owner may take possession of and utilize certain elements of the project as they are completed and placed into operation by the Contractor. The Contractor shall allow the Owner use of completed portions of the Work as necessary to maintain an effective system. Contractor shall plan the Work accordingly, in close coordination with the Engineer and Owner so as to maintain all vital system operations.
- B. For Warranty purposes, the warranty period as called for by the General and Supplemental General Conditions to the Specifications will start upon substantial completion of the entire project.

#### 1.17 REFERENCES



- A. Conform to reference standard by date of issue current as of date of Contract.
- B. The applicable codes and standards referred to in these specifications shall establish minimum requirements for materials, equipment, and installation, except where more stringent requirements are called for on the Drawings or elsewhere in the Contract Documents. Any conflict between the referenced codes and standards and the Drawings and Specifications shall be resolved by the Engineer and Owner, whose decision shall be binding upon all parties. All codes and standards referenced shall be the latest revision at the time of bidding.

#### 1.18 TEMPORARY ELECTRIC POWER

- A. Contractor shall provide and pay for power services required from source.

#### 1.19 TEMPORARY WATER

- A. Little Rock Water Reclamation Authority is NOT the Owner of the potable water distribution system within the project limits. The Contractor shall contact the Owner (Central Arkansas Water) of the water distribution system in the area of construction.
- B. The Contractor shall connect to the water distribution system in accordance with all requirements of the owner of the water distribution system. The Contractor shall install a backflow prevention device and meter as required by the owner of the water distribution system.
- C. The Contractor shall be responsible for any fees and water use charges as may be charged to the Contractor by the owner of the water distribution system.
- D. **The Contractor shall not use individual homeowners or business utilities, including water, for construction activities.**

#### 1.20 SANITARY FACILITIES

- A. Contractor shall provide and maintain required sanitary facilities and enclosures for the appropriate handling and disposal of all human waste, solid waste, and construction waste.
- B. Maintain clean and sanitary conditions.

#### 1.21 TEMPORARY WATER CONTROL

- A. Maintain excavations and trenches free of water. Provide and operate pumping equipment of a capacity to control water flow
- B. Provide dewatering system and pumping to maintain excavations dry and free of water inflow on a 24-hour basis.
- C. Provide piping to handle pumping outflow to discharge in a manner to avoid erosion or deposit of silt.

#### 1.22 TEMPORARY ACCESS ROADS AND PARKING

- A. Construct and maintain temporary construction access roads, parking areas, and detours as are required to execute the Work.



#### 1.23 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

- A. Remove temporary erosion control construction, above grade or buried utilities, equipment, facilities, and materials, prior to Substantial Completion inspection.
- B. Remove and repair damage caused by installation or use of temporary work.

#### 1.24 CONTRACT CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and Work is complete in accordance with Contract Documents and ready for Engineer and Owner's inspection.
- B. Submit final Application for Payment identifying total adjusted Contract Price, previous payments, and amount remaining due.

#### 1.25 CLEANING AND DISPOSAL

- A. Maintain areas free of waste materials, debris, rocks, roots, stumps, limbs, and rubbish. Maintain site in a clean and orderly condition. No trash shall be burned or buried on the job site and shall be properly disposed of by the Contractor.
- B. Execute final cleaning prior to final inspection.
- C. Drainageways, street surfaces and shoulders, driveways, lawns and landscaping, culverts, and all areas affected by construction shall be restored to equal or better than original condition. Ditches and drainageways shall be left clean and unobstructed and restored to their original cross-section and grade. Culverts shall be left "open" and free-flowing.

#### 1.26 FENCE RESTORATION

- A. The Contractor shall be responsible for maintenance of fences during construction. The Contractor shall provide as necessary temporary fencing, gates, etc., as may be required to afford access to the construction site and maintain the full integrity of the fence.
- B. All fences disturbed by construction activity shall be restored to their original condition or better using fencing materials that are of the same size, metal gauge, lumber, and character as the original fence.

#### 1.27 CHANGE ORDER PROCEDURES

- A. Submit itemized list of quantities and supporting data to Engineer for preparation of change order.

#### 1.28 PROJECT RECORD DOCUMENTS

- A. Maintain on site, one set of Contract Documents, approved Shop Drawings, and Product Submittals to be utilized for record documents.
- B. Record actual revisions to the Work concurrent with construction progress.
- C. Specifications, Record documents, and Shop Drawings: Legibly mark each item to record actual construction or product installed.
- D. Submit documents to Owner with final Application for Payment.



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## RIGHT-OF-WAY

- A. The lands upon which the Work is to be performed, rights-of-way and easements for access thereto and other lands designated for use by Contractor in performing the Work are identified on the Drawings. All additional lands and access thereto required for temporary construction facilities or storage of materials and equipment are to be provided by Contractor. Easements for permanent structures or permanent changes in existing structures are to be obtained and paid for by Owner.
- B. Record actual revisions to the Work concurrent with construction progress.
- C. Specifications, Record documents, and Shop Drawings: Legibly mark each item to record actual construction or product installed.

## 1.30 RESTORATION OF INFRASTRUCTURE, IMPROVEMENTS, STRUCTURES, ETC.

- A. The Contractor shall be responsible for repairing and/or replacing any public or private infrastructure, retaining walls, streets, drives, sidewalks, miscellaneous pavements, landscaping, sodding, brick pavers, fencing, irrigation systems, utilities, etc. damaged or disturbed by the Contractor during construction of the project.
- B. All improvements damaged or disturbed by construction activity shall be restored to their original condition or better using materials that are of the same size, metal gauge, lumber, and character as the original improvement and/or structure.
- C. Contractor shall take necessary precautions to prevent disturbance to private property. Contractor shall use plywood sheets or other method to prevent rutting caused by equipment in yards and other areas used for access. All areas disturbed by construction activity and access shall be sodded or seeded in accordance with specifications and as shown on the Drawings. Contractor shall repair any ruts caused by construction activity.
- D. All repair and replacement work shall be as approved by Engineer and/or Owner.

## PART 2 - PRODUCTS

Not used.

## PART 3 – EXECUTION

Not used.

END OF SECTION



## SECTION 01220

### MEASUREMENT AND PAYMENT

#### PART 1 – GENERAL

##### 1.1 SECTION DESCRIPTION

- A. This Section stipulates the method of measurement and payment for items of Work for which Unit Prices and Lump Sum Prices are stated in the Bid Form.
- B. The bid item price shall include all Work, as required by the Contract Documents, to complete the specified work listed on the Bid Form. The Work shall include all labor, materials, equipment, tools, and other such incidentals as required.
- C. All Work not specifically set forth as a pay item on the Bid Form or addressed herein, but nonetheless required for the complete and successful performance of the Work, shall be considered an obligation of the Contractor and subsidiary to the principle contract unit price for bid items requiring such materials and/or work. The cost of such subsidiary work shall be considered as included in the unit bid price required for the successful completion of the principle items of work indicated, and will not be paid outside of, or in addition to, the pay items shown on the Bid Form.

##### 1.2 SCOPE OF PAYMENT

- A. Units of measurement of items of Work for which Unit and/or Lump Sum Prices are stated will be as herein subsequently defined.
- B. The estimated quantities for items of Work for which Unit Prices are given in the Bid Form are subject to variation, and payment shall be based upon the final measurement of the items of work actually successfully completed and accepted. This project is federally funded through the Clean Water State Revolving Loan Fund (RLF) and administered by the Arkansas Natural Resources Commission (ANRC). Approval of payment includes reviews by the funding agency (ANRC), the Engineer, and the Owner; as well as the submission of all required information for processing payment. Refer to specification Section 00700 "General Conditions" and Section 00712 "RLF Supplemental General Conditions" for information regarding approval of payment and the general payment review process. Section 00712 "RLF Supplemental General Conditions" shall govern in matters pertaining to the payment process if in conflict with Section 00700 "General Conditions".

##### 1.3 ESTIMATED QUANTITIES

- A. Quantities stipulated in the Bid Form or Contract Documents are approximate and are to be used only as a basis for estimating the probable cost of the Work and for comparing the bids submitted for the Work. The actual amounts of work done and materials furnished under unit price items may differ from the estimated quantities.
- B. Payments will be made, in accordance with the Contract Documents, for actual quantities utilized or installed, with said quantities being measured as specified herein. Each bid item will be measured and paid for by the units defined on the Bid Form, at the Item Unit Cost submitted and awarded.
- C. Contractor agrees that he will make no claim for damages, anticipated profits, or otherwise on account of any difference between the amounts of work actually performed, materials actually furnished, actual tools and equipment required and the estimated amounts thereof.



## MEASUREMENT AND PAYMENT

- A. **Item No. 1 – FOG Receiving Station.** Construction of the new FOG receiving station that includes a concrete slab, truck off-loading concrete pad, canopy, process equipment, and associated piping, electrical installation, and instrumentation. The station includes a truck off-loading pump (and uninstalled spare), a rock trap/grinder, a FOG storage tank, a heating and recirculation system, and a digester feed pump (and uninstalled spare). The heating and recirculation system includes a FOG recirculation pump, a water to FOG heat exchanger, and two hot water pumps.
- B. **Item No. 2 – Primary Digester No. 5 Mixing System.** Demolition of the existing primary digester no. 5 gas mixing system. Installation of a new pump mixing system that includes two pumps, mixing nozzles, and associated piping, electrical installation, and instrumentation. Repairs and modifications to building structures and digesters.
- C. **Item No. 3 – Primary Digester No. 6 Mixing System.** Demolition of the existing primary digester no. 6 gas mixing system. Installation of a new pump mixing system that includes two pumps, mixing nozzles, and associated piping, electrical installation, and instrumentation. Repairs and modifications to building structures and digesters.
- D. **Item No. 4 – Waste Gas Burner System.** Demolition of the three existing waste gas burners. Construction of a new waste gas burner system that includes a concrete slab, two waste gas burners with propane fueled ignition systems, sediment trap, and associated piping, electrical installation, and instrumentation.
- E. **Item No. 5 – Electrical Modifications.** Modifications required to provide electrical power to the FOG receiving station, primary digesters nos. 5 and 6 mixing systems, and new waste gas burner system.
- F. **Item No. 6 – Primary Digester No. 5 Cleaning.** Cleaning of primary digester no. 5 including dewatering, hauling and disposal of anaerobic digester contents.
- G. **Item No. 7 – Primary Digester No. 6 Cleaning.** Cleaning of primary digester no. 6 including dewatering, hauling and disposal of anaerobic digester contents.
- I. **Item No. 8 – Storm Water Permit, Pollution Prevention Plan and Siltation Control.** Preparation of the Storm Water Permit and Storm Water Pollution Prevention Plan, and siltation control, shall be paid for at the stated lump sum amount for the job requirement as stated in the Bid Form. The lump sum amount shall include all labor, equipment, tools, cost of storm water permit fees, preparation of storm water permit and pollution prevention plan, siltation control, barriers and filters, silt fencing, and compliance with all aspects of the storm water permit and pollution prevention plan, all work, equipment, materials, and other costs related to the work called for in Section 01573 "Temporary Erosion and Sediment Control" of these specifications. The lump sum amount shall be paid based upon the percentage of work that is completed.
- H. **Item No. 9 – Mobilization.** This item shall compensate the Contractor for mobilization to the site of work for the execution of the contract, and shall not limit site visits for completion of the Work and shall not prevent the Contractor from returning to the site of work multiple times. The bid amount for mobilization of 5% shall include all preparatory work, transportation, and operations necessary for movement of personnel, equipment, supplies, and incidentals to the various sites of work throughout the execution of the contract, at the frequency required to complete the Work. This bid item shall include all requirements for any establishment of temporary offices, storage locations or storage buildings, sanitary facilities, and other facilities, as necessary, to undertake the Project. Work and operations which must be performed, or for expenses incurred, prior to beginning work on the Project, and any preconstruction costs (not including bidding costs) and not directly attributable to other pay items in this Section, shall be incidental to this bid item. No additional payment shall be allowed for multiple mobilization operations, site visits, delivery, transportation, or other mobilization related activities, and shall be as required to provide a complete and functional system as required by the Contract Documents.

END OF SECTION







## SECTION 01573

### TEMPORARY EROSION AND SEDIMENT CONTROL

#### PART 1 - GENERAL

##### 1.1 SUMMARY

- A. In all respects during prosecution of the Work called for by the Contract Documents, Contractor shall minimize the discharge of stormwater pollutants from the construction activity.
- B. The work shall be planned and executed so as to prevent siltation of area streams, ditches, swales, and drainages.
- C. Barriers and filters shall be constructed as necessary by the Contractor to intercept and impede silt or debris laden runoff from the construction site and prevent excessive quantities of silt and debris from reaching area streams and drainages.
- D. If disturbed area is greater than 1 acre, the Contractor shall complete all required forms in order for the Owner to obtain a National Pollution Discharge Elimination System (NPDES) Storm Water Permit and the Contractor shall prepare a Storm Water Pollution Prevention Plan (SWPPP) for the project in accordance with Arkansas Department of Environmental Quality (ADEQ) regulations. The Contractor shall be responsible for all fees, notices, notice of intent, notice of termination, disclosure statements, etc. associated with obtaining the Storm Water Permit. The Contractor shall submit all required forms and the SWPPP to the Engineer for Owner signature and forwarding to ADEQ.
- E. If the disturbed area is greater than 1 acre, the Contractor shall complete all required forms and prepare the Storm Water Pollution Prevention Plan and send to the Owner for signature and forwarding to ADEQ.
- F. If the disturbed area is less than 1 acre, the Notice of Coverage (NOC) and the SWPPP are not required. The Contractor shall prepare a drawing showing location and details of silt fences, barriers, etc. that the Contractor plans to install. The Contractor shall give the drawing to the Owner and Engineer for review. The Contractor shall follow Best Management Practices (BMP's) in accordance with ADEQ requirements.
- G. The Contractor shall be responsible for implementing the SWPPP (if a SWPPP is required by ADEQ), maintenance of the SWPPP, conducting inspections, implementing best management practices, site posting, and responsible for plan amendments. Contractor shall be responsible for the cost of all claims, losses, fines, penalties, or damages charged to Owner or Engineer due to Contractor's failure to comply with the requirements of the NPDES Storm Water Permit.
- H. Contractor shall, on Owner/Operator's behalf, execute all applicable requirements and discharge all duties as may be required for this project as described in ADEQ issued Construction General Permit titled "Authorization to Discharge Stormwater Under the National Pollutant Discharge Elimination system and the Arkansas Water and Air Pollution Control Act" including, but not limited to:
  - 1. Complete and post the NOC using forms acceptable to ADEQ;
  - 2. Timely preparation of the SWPPP, using a format acceptable to ADEQ;
  - 3. Ensuring that the site is in compliance with any changes or updates of the Permit;





4. Select, install, implement, and maintain best management practices at the construction site that minimize pollutants in stormwater discharges so as to meet applicable water quality standards;
5. Provide qualified personnel to conduct inspections and prepare inspection reports;
6. Maintain a file on site containing documents required by the SWPPP;
7. Achieve final stabilization;
8. Prepare and submit the NOT;
9. Execute other requirements as may be required by ADEQ and the Permit.
10. The Contractor shall be responsible for all fees, notices, notice of intent, notice of termination, disclosure statements, etc. associated with obtaining the Storm Water Permit.

- I. The Contractor shall not begin construction before the Notice of Coverage (NOC) and SWPPP is posted at the construction site. According to current ADEQ regulations, if the disturbed area is less than 1 acre the NOC and SWPPP are not required. If the disturbed area will be less than one acre, the Contractor shall submit a letter to the Owner stating such. The Contractor shall be required to use Best Management Practices if the disturbed area is less than one acre.

## 1.2 SECTION INCLUDES

- A. Temporary measures required to control erosion and sediment during construction. This includes measures to meet the requirements of the NPDES administered by the Environmental Protection Agency and the Arkansas Department of Environmental Quality.
- B. Stabilized construction entrance.
- C. Silt fence.
- D. Rock Check/Sand Bag Dams
- E. Storm Water Pollution Prevention Plan (SWPPP).

## 1.3 REFERENCES

- A. ASTM D751--Coated Fences.
- B. ASTM D3786--Hydraulic Bursting Strength of Knitted Goods and Non-woven Fabrics.
- C. ASTM A116--Zinc Coated (Galvanized) Steel Woven Wire Fence Fabric.
- D. ASTM D698--Test for Moisture Density Relations for Soils (Standard).

## 1.4 SUBMITTALS

- A. Submit in accordance with Section 01330 - Submittals.
- B. Submit the SWPPP.
- C. Product Data:
  1. Silt fencing.
  2. Non-woven filter fabric



D. Inspection Reports and Certificates:

1. Submit periodic inspection reports and certificates required for SWPPP.
2. Submit Contractor/Subcontractor certifications required for SWPPP.

E. Submit revisions or modifications to the erosion and sediment control plan and SWPPP.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. **Hay bales shall not be used for check dams.** Hay may be used for temporary stabilization of areas when spread. Hay bales shall be free of seeds.
- B. Stone material shall consist of rip-rap conforming to Arkansas Department of Transportation Standard Specifications and shall be placed as shown or in a layer of at least 12 inches thick.
- C. Geotextile Fabrics shall be a non-woven polypropylene fabric designed specifically for use as a soil filtration media. Fabric shall have an approximate weight of 6 oz/yd<sup>2</sup>, and shall conform to the following:

<u>Designation</u>	<u>Topic</u>	<u>Value</u>
ASTM D4632	Grab Strength (lbs.)	200
ASTM D4632	Grab Elongation	15%
ASTM D4533	Trapezoidal Tear (lbs.)	50
ASTM D751	Burst (psi)	320
ASTM D751	Puncture (psi)	80

ASTM D4751 Equivalent Opening Size (EOS) (mm)-soil retention.

<u>For Soils in Which:</u>	<u>EOS:</u>
50% or less passes a #200 mesh sieve	Greater than a #30 sieve
More than 50% passes a #200 mesh sieve	Greater than a #50 sieve

ASTM D4491 Permeability (k):

<u>For Soils in Which:</u>	<u>EOS:</u>
Critical/Severe:	k (fabric) >10k (soil)
Normal Applications:	k (fabric) >k (soil)

- D. Geotextile Silt Fence Fabric shall be a nylon reinforced polypropylene fabric having a reinforcing cord running the entire length to the top edge of the fabric. The fabric must meet or exceed the following criteria:

<u>Test Designation</u>	<u>Topic</u>	<u>Average Roll Minimum Value</u>
ASTM D4632	Grab Strength (lbs.)	90 lbs. @ 12"/minute
ASTM D4632	Grab Elongation	15% @ 12"/minute
ASTM D4751	Equivalent Opening Size (EOS)	U.S. sieve No. 20
ASTM D4491	Permittivity	>.01 sec.-1
ASTM D4355	U.V Resistance (500 hours exposure)	70%

- E. Fence Posts for Silt Fence shall be steel "T" posts of sufficient length to support the silt fence system.



- F. Woven Wire Support for Silt Fence: W1.4, 4" x 4", zinc coated (galvanized) steel woven wire fabric conforming to ASTM A116.
- G. Corrugated Metal Pipe: 16 gauge helical wound galvanized corrugated metal pipe.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION AND PREPARATION**

- A. The Contractor shall be responsible for reading and being thoroughly familiar with the permit and the storm water pollution prevention plan (SWPPP).
- B. The Contractor shall follow all requirements of ADEQ Short Term Activity Authorizations and Corps of Engineers Permits.
- C. Locate and protect survey horizontal and vertical control.
- D. Contractor shall install silt fencing along the low side of clearing limits (minimum) and in other areas as necessary to prevent siltation of area streams, ditches, swales, and drainages.

### **3.2 MAINTENANCE**

- A. Maintain erosion control devices as necessary to comply with the NPDES Storm Water Permit and Pollution Prevention Plan. This includes any revisions or modifications to the SWPPP. Any work required for modifications, revisions and maintenance shall be the responsibility of the Contractor and shall not be a basis for additional compensation.
- B. Maintain existing erosion and sedimentation control systems located within the project site.
- C. Inspect and repair or replace components of all erosion and sedimentation control systems as specified for each type of system. Unless otherwise directed, maintain the erosion and sedimentation control systems until the project is accepted by the Owner. Remove erosion and sedimentation control systems promptly when directed by the Owner. Discard removed materials off site.
- D. Equipment and vehicles shall be prohibited by the Contractor from maneuvering on areas outside of dedicated rights-of-way and easements for construction. Damages caused by construction traffic to erosion and sedimentation control systems shall be repaired immediately.
- E. Remove and dispose of sediment deposits. Offsite disposal will be the responsibility of the Contractor. Sediment to be placed at the project site shall be spread, compacted and stabilized in accordance with the Owner's directions. Sediment shall not be allowed to flush into stream or drainage way. If sediment has been contaminated, it shall be disposed of in accordance with existing federal, state and local regulations.



- F. Unless otherwise indicated, compact embankments, excavations, and trenches by mechanically blading, tamping, and rolling soil in maximum 8-inch lifts. Compaction density shall be at a minimum of 90 percent Standard Proctor ASTM D-698 density. Protect embankments from erosion by grassing or other Owner approved methods.

### 3.3 TEMPORARY HAY BALE DIKE

- A. Temporary hay bale dikes shall not be used.
- B. Hay may be used for temporary stabilization of areas if spread.

### 3.4 CONSTRUCTION ENTRANCE

- A. When necessary, wheels must be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone (Type "A" rip-rap) which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch or watercourse using approved methods.

### 3.5 SILT FENCE

- A. Silt fences shall be constructed as needed and as required by the NPDES permit to prevent siltation of area streams, ditches, swales, and drainages.
- B. Silt fence shall consist of nylon reinforced polypropylene netting supported by woven wire mesh, W1.4 x W1.4 and galvanized steel posts set a minimum depth of 2 feet and spaced not more than 6 feet on center. A 6-inch wide trench is to be cut 8 inches deep at the toe of the fence on the uphill side to allow the fabric to be laid below the surface and backfilled. Fabric shall overlap at abutting ends a minimum of 3 feet, and shall be joined such that no leakage or bypass occurs. Remove accumulated sediment when the depth reaches 6 inches.

### 3.6 ROCK CHECK/ SAND BAG CHECK DAM

- A. Rock Check/Sand Bag Dams shall be constructed as needed and as required by the NPDES permit to reduce velocity in channels. Geotextile fabric shall be placed beneath the rock and shall conform to these specifications.

### 3.7 SEDIMENT BASIN WITH STONE AND PIPE OUTLET

- A. Provide sediment basins as needed and as required by the NPDES permit at locations as needed by Contractor's construction sequence and operations.
- B. Install stone and pipe outlets for sediment basin at location shown and/or located as needed by Contractor's construction sequence and as required by the NPDES permit.
- C. Inspect sediment basin after each rainfall, daily during periods of prolonged rainfall, and a minimum of once a week. Maintain basin dimensions necessary to obtain the needed basin volume. Repair and replace damaged components of the basin.



## DIVERSION DIKE

- A. Diversion dikes shall be installed prior to and maintained for the duration of construction and shall intercept no more than five (5) acres of runoff. Dikes shall have a minimum top width of 2 feet and a minimum height of compacted fill of 18" measured from the top of the existing ground at the up-slope toe to top of the dike and having side slopes of 3:1 or flatter. The channel which is formed by the dike must have a minimum slope of one (1) percent for the entire length to an outlet. When the slope exceeds three (3) percent, or velocities exceed one foot per second (regardless of slope), stone stabilization is required. Plant grass on dikes not requiring stone stabilization.

END OF SECTION



## SECTION 02050

### SOILS AND AGGREGATES FOR EARTHWORK

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Aggregate base course.
  - 2. Granular fill.
  - 3. Native material.
  - 4. Sand.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. C117 - Standard Test Method for Materials Finer than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing.
  - 2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
  - 3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
  - 4. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
  - 5. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
  - 6. D4829 - Standard Test Method for Expansion Index of Soils.
  - 7. Arkansas Department of Transportation Manual of Standard Specification for Highway Construction

##### 1.03 SUBMITTALS

- A. Product data:
  - 1. Material source.
  - 2. Gradation.
  - 3. Testing data.
- B. Quality control for aggregate base course:
  - 1. Test reports: Reports for tests required by Sections of Arkansas Department of Transportation Standard Specifications.
  - 2. Certificates of Compliance: Certificates as required by Sections of Arkansas Department of Transportation Standard Specifications.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.



## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. General:
  - 1. Provide material having maximum particle size not exceeding 2 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.
  - 2. Materials derived from processing demolished or removed asphalt concrete are not acceptable.
- B. Aggregate base course:
  - 1. ARDOT Standard Specification for Highway Construction 303 Aggregate Base Course Class 7.
- C. Granular fill material:
  - 1. Consists of clean, sound earthen material for which the plasticity index when tested in accordance with ASTM D4318 shall be between 7 to 15.
  - 2. The organic content shall not be greater than 2 percent by volume.
  - 3. Liquid limits shall be less than 35 percent by volume.
  - 4. Conform to size and grade when tested in accordance with ASTM C117 and ASTM C136 as follows:
    - a. 100 percent passing the 2-inch sieve.
    - b. 100 – 70 percent passing the 3/4-inch sieve.
    - c. 25 – 15 percent passing the No. 4 sieve.
    - d. 10 – 0 percent passing the No. 200 sieve.
- D. Native material:
  - 1. Sound, earthen material passing 1-inch sieve.
  - 2. Percent of material by weight passing Number 200 sieve shall not exceed 30 when tested in accordance with ASTM C136.
  - 3. Expansion index less than 35 when tested in accordance with ASTM D4829.
- E. Sand:
  - 1. Clean, coarse, natural sand.
  - 2. Non-plastic when tested in accordance with ASTM D4318.
  - 3. 100 percent shall pass a 1/2-inch screen.
  - 4. No more than 20 percent shall pass a Number 200 sieve.

## **PART 3 EXECUTION**

Not Used.

END OF SECTION



## **SECTION 02200**

### **SITE CLEARING**

#### **PART 4 GENERAL**

##### **4.01 SUMMARY**

- A. Section includes: Clearing, grubbing, and stripping project site.

##### **4.02 REFERENCES**

##### **4.03 DEFINITIONS**

- A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.
- B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.
- C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the Engineer.

##### **4.04 QUALITY ASSURANCE**

- A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.
- B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

##### **4.05 PROJECT CONDITIONS**

- A. Environmental requirements:
  - 1. For suspected hazardous materials found: As specified in Section 01354 - Hazardous Material Procedures.

##### **4.06 SEQUENCING AND SCHEDULING**

- A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.





## **PART 5 PRODUCTS**

Not Used.

## **PART 6 EXECUTION**

### **6.01 EXAMINATION**

- A. Verification of conditions: Examine site and verify existing conditions for beginning work.

### **6.02 PREPARATION**

- A. Protect existing improvements from damage by site preparation work.

### **6.03 INSTALLATION**

- A. Clearing:
  - 1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
  - 2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
  - 3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.
- B. Grubbing:
  - 1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
  - 2. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.
- C. Stripping:
  - 1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
  - 2. Replace topsoil in areas disturbed during construction.

END OF SECTION



## SECTION 02240

### DEWATERING

#### PART 7 GENERAL

##### 7.01 SUMMARY

- A. Section includes:
  - 1. Installation and maintenance of dewatering systems.
  - 2. Disposal of water entering excavation or other parts of the work.

##### 7.02 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
  - 2. Dewatering design analysis. Include the following:
    - a. Evaluation of anticipated subsurface conditions.
    - b. Required well spacing.
    - c. Diameter of wells.
    - d. Depth to screen, screen height, and mesh size.
    - e. Backfill and filter pack.
    - f. Pump size.
    - g. Drawdown duration.
    - h. Drawdown and steady state flow rates.
    - i. Plans for de-silting of groundwater before discharge.
    - j. Expected settlements.
  - 3. Include water drawdown curves in dewatering calculations.
  - 4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.
  - 5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
  - 6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to finished grade.
  - 7. Provide standby power to ensure continuous dewatering in case of power failure.
- B. Dewatering shored excavations:
  - 1. Dewater from within shoring.
  - 2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
  - 3. Extend impermeable shoring below bottom of excavation sufficient amount to:
    - a. Minimize lowering of groundwater outside shoring.
    - b. Prevent unstable excavation due to piping and heave.



4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.
  5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.
- C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.
- D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.
- E. Discharge:
1. Discharge to storm drain manholes or storm drain inlets will be permitted.

### 7.03 SUBMITTALS

- A. Dewatering plan:
1. Dewatering design analysis.
  2. Required permits.
  3. Arrangement, location, and depths of dewatering system components.
  4. Type and sizes of filters.
  5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location. For pipes discharging to manholes, provide details of pipe entry at manhole.
- B. Well construction logs. Include:
1. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
  2. Construction details.
  3. Well development procedures and results.
  4. Deviations from original design.
- C. Qualifications:
1. Dewatering contractor.
  2. Dewatering design engineer.
  3. Testing laboratory.

### 7.04 QUALITY ASSURANCE

- A. Dewatering plan and dewatering system analysis:
1. Prepared by a qualified Civil Engineer, licensed in the state where the Project is located.
    - a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.
- B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.
- C. Testing laboratory shall meet discharge permit testing laboratory qualifications.
- D. Regulatory requirements:
1. Obtain required water discharge permits.



## **PART 8 PRODUCTS**

Not Used.

## **PART 9 EXECUTION**

### **9.01 INSTALLATION**

- A. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.
- B. Keep excavations reasonably free of water.
- C. Make provisions to maintain continuous dewatering:
  - 1. Provide standby power to maintain dewatering during power outages and interruptions.
  - 2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.
- D. Intercept and divert precipitation and surface water away from excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.
- E. Disposal of water:
  - 1. Dispose of water from the work in suitable manner without damage to adjacent property.
  - 2. Do not drain water into work built or under construction.
  - 3. Dispose of water in such manner that it will not be a menace to public health or safety.
- F. Wells, well points, and drain lines for dewatering:
  - 1. Provide after receiving Engineer's written acceptance.
  - 2. Fill dewatering wells, pipes, and french drains to be left in place within structure foundation limits with Class "C" concrete as specified in Section 03300 - Cast-in-Place Concrete or grout as specified in Section 03600 - Grouting.

### **9.02 CONSTRUCTION**

- A. Prior to release of groundwater to its static level: Confirm that:
  - 1. All groundwater pressure relief devices for structure are fully operational.
  - 2. Construction of structure is complete and concrete has reached its specified compressive strength.
  - 3. Backfill of structure is complete.
- B. Control release of groundwater to its static level to prevent disturbance of natural foundation soils or compacted backfills and fills and to prevent flotation or movement of structures, pipelines, or other facilities.

END OF SECTION



## SECTION 02260

### EXCAVATION SUPPORT AND PROTECTION

#### PART 10 GENERAL

##### 10.01 SUMMARY

- A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

##### 10.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
  - 1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

##### 10.03 DEFINITIONS

- A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
- B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.
- C. Support levels: Level of tiebacks, wales, rackers, bottom of excavation, and other types of support.

##### 10.04 SYSTEM DESCRIPTION

- A. Where General Engineering Design Practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
  - 1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
  - 2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.
- B. Design requirements:
  - 1. General:
    - a. For trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in.
      - 1) Perform design pursuant to general engineering design practice.
    - b. Dewatering:
      - 1) Dewater soil inside shoring as specified in Section 02240 - Dewatering for Structures.
      - 2) Do not lower groundwater outside of shoring more than 1 foot.



- 3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
  - c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
  - d. Minimum safety factor used for design shall not be less than 1.5.
  - e. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
  - f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
  - g. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
  - h. Generally acceptable references for design of shoring and excavations are as follows:
    - 1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
    - 2) Caltrans California Trenching and Shoring Manual.
    - 3) NAVFAC Design Manual 7.2.
    - 4) NAVFAC Design Manual 7.3.
    - 5) USS Steel Sheet Piling Design Manual.
2. Soldier piles and lagging:
- a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
  - b. Provide full face lagging all around penetrations through lagging.
  - c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 02312 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
  - d. Assumed effective width for passive soil resistance:
    - 1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
    - 2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
    - 3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
  - e. Fill voids behind lagging with gravel or other material acceptable to Engineer.
  - f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
    - 1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
    - 2) Do not eccentrically load structural section of soldier piles or wales.
  - g. Design soldier piles for downward loads including vertical loads from tieback anchors.
3. Soil anchors, rock anchors, and deadman anchors:
- a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
  - b. Proof load all production anchors to 125 percent of calculated load from shoring.



- c. Lock off production anchors at calculated load from shoring.
    - d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
    - e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
    - f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.
  - 4. Set inside face of shoring back from structure not less than greater of following:
    - a. 5 feet from face of wall.
    - b. 2 foot 6 inches from edge of foundation.
    - c. Depth of excavation below bottom of foundation.
- C. Performance requirements:
- 1. General:
    - a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
    - b. Specified provisions:
      - 1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
      - 2) Represent minimum requirement for:
        - a) Number and types of means needed to maintain soil stability.
        - b) Strength of such required means.
        - c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
  - 2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
  - 3. Provide support for trench excavations for protection of workers from hazard of caving ground.
  - 4. Provide shoring:
    - a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
      - 1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
      - 2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
    - b. For trenches 5 feet and deeper.
    - c. For trenches less than 5 feet in depth, when there is potential for cave-in.
    - d. Where indicated on the Drawings.
  - 5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:



- a. Using stiff shoring systems.
- b. Following appropriate construction sequence.
- c. Using shoring system that is tight enough to prevent soil loss through the shoring.
- d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
- e. Design for safety factor of not less than 1.50.
- f. Providing surface runoff routing and discharge away from excavations.
- g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
- h. Where sheet piling is used, use interlocking type sheets:
  - 1) Sheet piles shall be continuous and driven in interlock.
  - 2) If bottom of the excavation is located below the water table, use "ball and socket" or "thumb and finger" type interlock.
- i. Not applying shoring loads to existing structures and other improvements.
- j. Not changing existing soil loading on existing structures and other improvements.
- k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds **1/2** inch before wales are loaded.

#### **10.05 SUBMITTALS**

- A. Shop drawings and calculations:
  - 1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
  - 2. Sketches showing the condition at various stages of installation and removal of shoring.
  - 3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
  - 4. When utilities penetrate shoring, show location of penetrations on elevation of all sides of shoring.
  - 5. Show details for ground support and sealing around utility penetrations.
  - 6. Indicate method used for installing driven shoring.
- B. Control points and schedule of measurements:
  - 1. Submit location and details of control points and method and schedule of measurements.
  - 2. Survey data.
- C. Detailed sequence of installation and removal of shoring:
  - 1. Consider effects of ground settlement in sequence of installation and removal of shoring.
  - 2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.
- D. Submit submittals for excavation support and protection as complete package and include all items required in this Section:
  - 1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.





- E. Submit dewatering submittals as specified in Section 02240 - Dewatering for Structures with submittals for excavation support and protection.

#### **10.06 SEQUENCING**

- A. Do not begin construction of any shoring or excavation operations until:
  - 1. Submittals for shoring and dewatering have been accepted.
  - 2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
  - 3. Materials necessary for installation are on site.
- B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

#### **PART 11 PRODUCTS**

Not Used.

#### **PART 12 EXECUTION**

##### **12.01 CONSTRUCTION**

- A. Installation of shoring:
  - 1. Install means for providing safe and stable excavations as indicated in submittals.
- B. Removal of shoring:
  - 1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of Work.
  - 2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
  - 3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
    - a. Inject grout starting at bottom of void and progressively fill void to grade.
    - b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
  - 4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.
- C. Control points:
  - 1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
    - a. Set control points on shoring support system:
      - 1) Set points at distances not exceeding 25 feet at each support level.
  - 2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.



3. Perform horizontal and vertical survey and measurement of control points at least once every week:
    - a. Field notes shall show current measurement and change in measurement from first measurement taken.
  4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
- D. Maintenance:
1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
  2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

## SECTION 02300

### EARTHWORK

## PART 13 GENERAL

### 13.01 SUMMARY

- A. Section includes:
1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
  2. Backfilling and compacting under and around structures.

### 13.02 REFERENCES

- A. ASTM International (ASTM):
1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN m/m<sup>3</sup>)).
  3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

### 13.03 DEFINITIONS

- A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
- B. Embankments: Dikes, levees, berms, and similar facilities.
- C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for



purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

#### **13.04 SYSTEM DESCRIPTION**

- A. Performance requirements:
  - 1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
  - 2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
  - 3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

#### **13.05 SUBMITTALS**

- A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.
- B. Excavation plan.
- C. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.
- D. Test reports:
  - 1. Submit certified test reports of all tests specified to be performed by the Contractor.
  - 2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering registered in the state where the project is located.

#### **13.06 QUALITY ASSURANCE**

- A. Initial compaction demonstration:
  - 1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
    - a. 50 cubic yards of backfill adjacent to structures.
    - b. 100 cubic yards of embankment work.
    - c. 100 cubic yards of fill.
    - d. 50 cubic yards of roadway base material.
    - e. 100 cubic yards of road fill.
  - 2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
  - 3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."
- B. Contractor shall perform all work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP) and as specified in Section 01355A – Stormwater Pollution Prevention Construction Activities: Best Management Practices.



### 13.07 SEQUENCING AND SCHEDULING

- A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.
- B. If necessary, stockpile excavated material in order to use it at specified locations.
- C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

## PART 14 PRODUCTS

### 14.01 MATERIALS

- A. Water for compacting: Use water from source acceptable to Engineer.
- B. Soil and rock materials:
  - 1. General:
    - a. Provide aggregate base course, controlled low-strength material, granular fill material native material, and sand where specified or indicated on the Drawings.
    - b. If suitable surplus materials are available, obtain native material from cut sections or excavations.
  - 2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 3. Granular fill material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 4. Native material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 5. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Materials (CLSM).
- D. Geotextile fabrics:
  - 1. Stabilization fabric: As specified in Section 02620 – Stabilization Fabric.
  - 2. Stabilization fabric shall be used under backfill at concrete structures and pavement, under aggregate base course at paved areas, and under aggregate base course at gravel surfaced areas.

## PART 15 EXECUTION

### 15.01 EXAMINATION

- A. Verification of conditions:
  - 1. Character and quantity of material:
    - a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
    - b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.



- c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
- d. Include wasting of excess material, if required, in cost of work to be performed.

## 15.02 PREPARATION

- A. Backfills:
  - 1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompact scarified areas to density specified before placing backfill material or concrete.
  - 3. Do not place backfill against walls until:
    - a. Walls have been cast full height of structure and concrete has reached the specified strength.
    - b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
  - 4. Prior to backfilling:
    - a. Remove all forms.
    - b. Clean all trash and debris from the excavation site.
  - 5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.
- B. Fills:
  - 1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.
- C. Roadway fills:
  - 1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.

## 15.03 INSTALLATION

- A. General:
  - 1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
  - 2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.



3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
  4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.
- B. Borrow area: There is no borrow area on Project site.
1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.
  2. There will be no additional cost to the Owner for use of imported material.
- C. Compaction:
1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
  2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
  3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1557, or with ASTM D6938.
  4. Maximum density obtained in laboratory when tested in accordance with ASTM D1557.
  5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
  6. Compact to percentage of maximum density as follows:
    - a. Backfill adjacent to structures: 95 percent.
    - b. Backfilling voids: 95 percent.
    - c. Other areas: 85 percent.
    - d. Under present and future structures: 95 percent.
    - e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
    - f. Upper 6 inches of cuts: 95 percent.
    - g. Fills: 95 percent.
- D. Dewatering: As specified in Section 02240 - Dewatering.
- E. Excavation:
1. Blasting: Not permitted.
  2. Excavations for structures:
    - a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure, including trenching for piping and all work incidental thereto.
    - b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
    - c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.



- d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
    - 1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
    - 2) Under footings: Restore to the proper elevation using one of the following:
      - a) Aggregate base course.
  - e. Excavation width:
    - 1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
    - 2) Do not undercut slopes.
  - f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
  - 3. Necessary over excavation:
    - a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
    - b. Backfill voids with material acceptable to the Engineer:
      - 1) With acceptance of the Engineer, backfill with one of the following:
        - a) Aggregate base course.
        - b) Controlled low-strength material.
- F. Materials for backfills, embankments, fills, and roadway fills:
- 1. General:
    - a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
  - 2. Backfills:
    - a. Backfill adjacent to structures, slabs, or walls: Native material Granular fill material or imported material meeting the requirements of native material granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
    - c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  - 3. Fills:
    - a. Native material Granular fill material or imported material meeting the requirements of native material Granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  - 4. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
    - a. Aggregate base course material.

G. Placement:



1. General:
  - a. Lines and grades:
    - 1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
    - 2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
2. Backfills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted backfills: Remove and recompact.
3. Fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted fills: Remove and recompact.
4. Roadway fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted roadway fills: Remove and recompact.

#### 15.04 FIELD QUALITY CONTROL

- A. Tests:
  1. Confirmation tests:
    - a. Contractor's responsibilities:
      - 1) Accomplish specified compaction for backfills, fills, and other earthwork.
      - 2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
      - 3) Cost of confirmation tests: Paid for by the Contractor.
      - 4) Qualifications of Contractor's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the Engineer.
      - 5) Copies of confirmation test reports: Submit promptly to the Engineer.
    - b. Frequency of confirmation testing:
      - 1) Perform testing not less than the following:
        - a) In-place density:
          - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
          - (2) Cuts: 20 cubic yards.
          - (3) Fills: 20 cubic yards.
          - (4) Roadway fills: 20 cubic yards.
        - b) Maximum dry density versus moisture:
          - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
          - (2) Cuts: 20 cubic yards.
          - (3) Fills: 20 cubic yards.





- (4) Roadway fills: 20 cubic yards.
- 2. Compliance tests:
  - a. Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
  - b. Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
  - c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
    - 1) Remove and replace materials at proper density.
    - 2) Bring density up to specified level by other means acceptable to the Engineer.
  - d. Retesting:
    - 1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
    - 2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.
- B. Tolerances:
  - 1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
    - a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
    - b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
  - 2. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
    - a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
    - b. Intent of proceeding is to avoid sandy or gravelly areas.
  - 3. Finish grading of surfaces:
    - a. Reasonably smooth, compacted, and free from irregular surface changes.
    - b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
    - c. Uniformly grade areas that are not under concrete.
    - d. Finish ditches and gutters so that they drain readily.

#### 15.05 ADJUSTING

- A. Finish grades of excavations, backfills, and fills:
  - 1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

#### 15.06 PROTECTION

- A. Finish grades of backfills, cuts, excavations, and fills:
  - 1. Protect newly graded areas from erosion and deterioration by action of the elements.
- B. Ditches and gutters:



1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

## SECTION 02312

### CONTROLLED LOW STRENGTH MATERIAL (CLSM)

#### PART 16 GENERAL

##### 16.01 SUMMARY

- A. Section includes: Controlled low strength material (CLSM), also known as "flowable fill."

##### 16.02 REFERENCES

- A. American Concrete Institute (ACI):
  1. 229R - Report on Controlled Low-Strength Materials.
  2. 301 - Specifications for Structural Concrete.
- B. ASTM International (ASTM):
  1. C94 - Standard Specification for Ready Mix Concrete.
  2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
  3. C150 - Standard Specification for Portland Cement.
  4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
  5. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
  6. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  7. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
  8. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
  9. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

##### 16.03 SYSTEM DESCRIPTION

- A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.
- B. Performance requirements:
  1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.



2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
3. Wet density: Not greater than 132 pounds per cubic foot.
4. Slump, measured in accordance with ASTM C143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.

#### **16.04 SUBMITTALS**

- A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
  1. Cement: Mill tests. Indicate alkali content representative of each shipment.
  2. Fly ash: Identify source and type of fly ash.
  3. Water: Identify source and quality if not from a municipal treatment source.
  4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.
  5. Aggregate:
    - a. Submit source, type, and sieve analyses.
    - b. Resubmit at any time there is a significant change in grading of materials.
- B. Mix design:
  1. Submit full details, including mix design calculations for mix proposed for use.
  2. Trial batch test data:
    - a. Submit data for each test cylinder.
    - b. Submit data that identifies mix and slump for each test cylinder.

#### **16.05 DELIVERY, STORAGE AND HANDLING**

- A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.
- B. Store admixtures in accordance with the manufacturer's recommendations.

### **PART 17 PRODUCTS**

#### **17.01 MATERIALS**

- A. Cement:
  1. Portland cement in accordance with ASTM C150 Type I or Type II.
  2. Having total alkali content not more than 0.60 percent.
- B. Fly ash: Class C or Class F fly ash in accordance with ASTM C618.
- C. Water:
  1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
- D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM.
  1. Air entraining admixture: In accordance with ASTM C260.



## 17.02 MIXES

- A. See System Description for performance requirements of the plastic and hardened mix.

## 17.03 SOURCE QUALITY CONTROL

- A. Trial batch:
  - 1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
  - 2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
  - 3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in the this Section.
- B. Trial batch testing:
  - 1. Determine slump in accordance with ASTM C143, with the following modifications:
    - a. Do not rod the concrete material.
    - b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
  - 2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
    - a. Provide cylindrical test specimens, each 6-inches in diameter by 12-inch high.
    - b. Provide a minimum of 8 cylinders for testing of each trial batch.
    - c. Fill the molds to overflowing and tap sides lightly to settle the mix.
    - d. Do not rod the mix for consolidation in the cylinder.
    - e. Strike off the excess material.
  - 3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
  - 4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested.
    - a. Perform the capping carefully to prevent premature fractures.
    - b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
  - 5. Provide compressive strength tests:
    - a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
    - b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
- C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced.
  - 1. All the trial batches and acceptability of materials shall be paid by the Contractor.
  - 2. After acceptance, do not change the mix design without submitting a new mix design, trial batches, and test information.



## **PART 18 EXECUTION**

### **18.01 PREPARATION**

- A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.
- B. Remove debris foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

### **18.02 INSTALLATION**

- A. Pipes and trenches.
  - 1. Install cellular concrete as indicated on the Drawings and specified.
  - 2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
  - 3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.
  - 4. Place CLSM at specified access points in the abandoned in-place pipe.
- B. Soil preparation:
  - 1. Prior to placement of CLSM, prepare underlying soils as follows:
    - a. Scarify surface to a depth of 8 inches.
    - b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D1557.
    - c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D1557.

### **18.03 MEASURING, BATCHING, MIXING AND TRANSPORTING**

- A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.
- B. Mix until there is uniform distribution of materials.
- C. Discharge mixer completely prior to recharging.
- D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

### **18.04 PLACING**

- A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.
- B. Maintain fluid properties of the mix during placement.
  - 1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
  - 2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
  - 3. Handle and place CLSM using methods that minimize segregation of the mix.



4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
  5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.
- C. Lifts:
1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
  2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.
- D. Water conditions:
1. Do not place CLSM in standing or flowing water.
  2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
  3. Do not submerge CLSM in water within 24 hours after placement.
- E. Manage CLSM bleed water.
1. Grade top surface of CLSM to drain away from the fill.
  2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

#### **18.05 CURING AND PROTECTION**

- A. Curing:
1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.
- B. Protect CLSM from:
1. Damage from the elements.
  2. Damage of any nature during surrounding construction operations.
  3. Freezing: Do not use salt, manure, or other chemicals to provide cold.

#### **18.06 FIELD QUALITY CONTROL**

- A. Provide quality control over the Work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan and as specified in this Section.
- B. General:
1. Engineer inspection and acceptance required prior to placement.
  2. Make provisions for and furnish all material for the test specimens, and provide manual assistance in preparing said specimens.

#### **18.07 FIELD QUALITY ASSURANCE**

- A. Provide quality control over the work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan.
- B. Field inspections:
1. Engineer shall provide on-site inspection for the Work of this Section.



2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
  3. Required inspections:
    - a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
  4. Record of inspections.
- C. Field sampling and testing:
1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
  2. Required tests:
    - a. Air content: Prepare sample and test in accordance with ASTM D6023
    - b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832.
      - 1) Prepare 6-inch diameter by 12-inch high specimens for testing.
        - a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
        - b) Prepare and test not less than 3 cylinders for each set.
        - c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
        - d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
      - 2) Place the cylinders in a safe location away from construction activities.
        - a) Protect cylinders from bumping and impact.
        - b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
        - c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.
      - 3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
        - a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
        - b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
      - 4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
      - 5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.
      - 6) Cap and test for compressive strength in accordance with ASTM D4832.
        - a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
        - b) Test 1 cylinder at 7 days and 2 at 28 days.
      - 7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.



#### 18.08 NON-CONFORMING WORK

- A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.
- B. Engineer may:
  - 1. Reject CLSM represented by those test specimens and require its removal and replacement.
  - 2. Require modification of the mix design to provide CLSM with the properties specified.
- C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION





## **SECTION 02318**

### **TRENCHING**

#### **PART 19 GENERAL**

##### **19.01 SUMMARY**

- A. Section includes: Trench excavation and trench backfill.

##### **19.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>).
  - 3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

##### **19.03 SUBMITTALS**

- A. As specified in Section 01330 - Submittal Procedures.
- B. Product data on soils and aggregates.
  - 1. Material source.
  - 2. Gradation.
  - 3. Test data to demonstrate compliance with this Section.
- C. Samples:
  - 1. Provide 50-pound sample of materials when requested by the Engineer.
- D. Confirmation testing:
  - 1. Certification of Contractor's testing laboratory.
  - 2. Record copy report for tests performed by Contractor's testing laboratory.

##### **19.04 DEFINITIONS**

- A. Backfill: Material placed in trench above the pipe embedment zone.
- B. Bedding: Material placed under, around, and over pipes or ducts in trenches.
- C. Center bedding: Material placed at the bottom of the trench directly under the center of the pipe to provide a malleable resting surface.
- D. Fine grading: Material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.



- E. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
- F. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
- G. Lift: A layer of soil or aggregate material, measured before compaction.
- A. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
- B. Maximum density, field compaction: Soil density and water content when tested in accordance with ASTM D1556.
- C. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
- D. Pipe embedment zone: Includes bedding, fine grading, center bedding, and haunch zone.
- E. Pipe foundation: Material placed at the bottom of trench to provide support.
- F. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.
- G. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

## **PART 20 PRODUCTS**

### **20.01 MATERIALS**

- A. As specified in Section 02050 - Soils and Aggregates for Earthwork.
- B. Class C concrete: As specified in Section 03300 - Cast-in-Place Concrete.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Material (CLSM).

## **PART 21 EXECUTION**

### **21.01 PREPARATION**

- A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.



## 21.02 DEWATERING

- A. As specified in Section 02240 - Dewatering.

## 21.03 TRENCH EXCAVATION

- A. Excavate bottom of trench to depth indicated on the Drawings.
- B. Areas of new fill or embankment:
1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
  2. Excavate through fill for pipe trench.
- C. Trench widths as specified in the following table:

Buried Pipe Or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

- D. Potable water pipe and appurtenances:
1. Lay in trenches separate from those used for sewers.
  2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.

## 21.04 TRENCH BACKFILL - GENERAL

- A. Trench area terminology and locations as indicated on the Drawings.
- B. Place material, except CLSM and concrete, in maximum 6 inch lifts, measured before compaction.
- C. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

## 21.05 PIPE FOUNDATION

- A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.
1. Prepare pipe foundation, with any unauthorized excess excavation below elevation indicated on the Drawings, at no additional cost to Owner.
- B. If bottom of trench excavation consists of soil:
1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.



2. Materials and placement:
  - a. Recompact scarified material to 95 percent of maximum density.
- C. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
  1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
  2. Materials:
    - a. CLSM.
    - b. Class C concrete.
- D. If bottom of trench excavation consists of unacceptable material:
  1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
  2. Material and placement:
    - a. Aggregate base course material compacted to 95 percent of maximum density.
      - 1) Maximum particle size for backfill material limited as specified in the following table:

Buried Pipe	Maximum Particle Size
Nominal Pipe Diameter: 6 inch to 8 inch	3/4 inch
Nominal Pipe Diameter: 10 inch to 16 inch	1 inch
Nominal Pipe Diameter: Greater than 18 inch	1 1/2 inches

#### 21.06 PIPE EMBEDMENT ZONE

- A. General:
  1. Pipe displacement:
    - a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
    - b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
  2. Depressions for joints or couplings:
    - a. Excavate holes in graded trench bottom.
    - b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
- B. Rigid pipe:
  1. Fine grading:
    - a. Compacted depth below bottom of pipe: 6 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
  2. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.



- C. Flexible pipe:
  - 1. Center bedding:
    - a. Compacted depth below bottom of pipe: 12 inch minimum.
    - b. Compacted width below bottom of pipe: 1/3 of pipe outer diameter.
    - c. Materials and placement:
      - 1) Sand bags.
      - 2) Uncompacted sand at uniform density, minimize compaction.
  - 2. Haunch zone:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.
  - 3. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.

## 21.07 BACKFILL

- A. Trenches:
  - 1. Materials and placement:
    - a. Native soil compacted to 95 percent maximum dry density.
    - b. Imported fill compacted to 95 percent maximum dry density.
    - c. Aggregate base course compacted to 95 percent maximum dry density.
    - d. CLSM.
- B. Trenches in rock:
  - 1. Backfill to top of rock.
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.
  - 2. Backfill from top of rock to grade, if applicable:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent of maximum density.
- C. Trenches below or within 10 feet of the outside perimeter of structures:
  - 1. Backfill within aggregate base course below structure.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- D. Trenches in roadways and paved areas:
  - 1. Backfill trench to underside of pavement.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- E. Trenches in areas outside the improved section of roadways or in open country:
  - 1. Backfill to finished grade.



2. Materials and placement:
  - a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.
- F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
  1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
    - a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
    - b. Materials and placement:
      - 1) CLSM, unless otherwise indicated on the Drawings.
  2. Backfill remainder of trench:
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.

#### **21.08 EXCESS MATERIAL**

- A. Remove excess excavated material from the Project site as specified in Section 02300 - Earthwork.

#### **21.09 FIELD QUALITY CONTROL**

- A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.
- B. Confirmation tests: As specified in Section 02300 - Earthwork.
  1. Minimum frequency of confirmation testing:
    - a. At each test location include tests for each type or class of backfill from bedding to finished grade.
    - b. For trenches: 1 location every 200 linear feet.
    - c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
    - d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
    - e. Crossing paved roads: 1 location at each crossing.
    - f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
- C. Compliance tests:
  1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
  2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
    - a. Remove and replace backfill at the proper density.
    - b. Other means acceptable to the Engineer.
  3. Retesting:
    - a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.



- b. Contractor's confirmation tests during performance of remedial work:
  - 1) Performance: Perform tests in manner acceptable to the Engineer.
  - 2) Frequency: Double amount specified for initial confirmation tests.
- D. Piping system testing:
  - 1. As specified in Section 15956 - Piping Systems Testing.

END OF SECTION



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## **SECTION 02600**

### **CONCRETE MANHOLES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Manhole frames and covers.
  - 2. Manhole grade rings.
  - 3. Manholes cones and risers.
  - 4. Manhole bases.

##### **1.02 REFERENCES**

- A. American Association of State Highway and Transportation Officials (AASHTO).
  - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
  - 1. A48 - Standard Specification for Gray Iron Castings.
  - 2. C33 - Standard Specification for Concrete Aggregates.
  - 3. C150 - Standard Specification for Portland Cement.
  - 4. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
  - 5. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
  - 6. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
  - 7. C923 - Standard Gide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.
  - 8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
- C. International Organization of Standardization (ISO):
  - 1. 9001 - Quality Management Standard.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings:
  - 1. Manufacturer's catalog data and details of following items for approval:
    - a. Frame and covers.
    - b. Grade rings.
    - c. Manhole cones and risers.
    - d. Manhole bases, if precast.
  - 2. Manhole construction details, jointing methods, connection details, materials, and dimensions.
  - 3. Repair procedures and details.





- C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.
- D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.
- E. Sealed drawings and design calculations by a registered Professional Engineer licensed in the State where the project is located.
- F. Certificates
  - 1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
  - 2. Manufacturer's Certificate of Source Testing.

#### **1.04 PRODUCT REQUIREMENTS**

- A. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
  - 1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
  - 2. Dragging or dropping the manhole components shall not be allowed.
- B. Source testing.
  - 1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
    - a. In lieu of this experience, witness of tests by up to 3 full-time Owner representatives.
  - 2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
  - 3. Complete required testing in accordance with ASTM C478.
  - 4. Provide the Manufacturer's Certificate of Source Testing.

#### **1.05 DESIGN CRITERIA:**

- A. Manholes shall not include steps.
- B. Manhole lids: Locking (watertight) type.
- C. Manhole bases:
  - 1. Constructed in accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
- D. Manhole riser:
  - 1. In accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
  - 2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.
- E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.



- F. Manhole systems:
  - 1. Provided by a single manufacturer.
- G. Frames and covers:
  - 1. Provided by a single manufacturer unless approved by the Engineer.

#### **1.06 WARRANTY**

- A. As specified in Section 01783 - Warranties and Bonds.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Manhole grade rings, cones, and risers: One of the following or equal.
  - 1. Peterson Concrete.
- B. Manhole frames and covers: Manufacturers: One of the following or equal.
  - 1. East Jordan Iron Works – Model V2418.
  - 2. Neenah Foundry Company.

#### **2.02 BASIS OF DESIGN**

- A. Design in accordance with local jurisdiction requirements and Little Rock Water Reclamation Authority Standard Details, including but not limited to the following:
  - 1. Manhole frames and covers.
  - 2. Manhole diameter tolerance.
  - 3. Manhole length.
  - 4. Manhole cover bolting.
  - 5. Manhole backfill.
- B. Structural design calculations:
  - 1. Load rating of manhole:
    - a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
  - 2. Resist buoyancy:
    - a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
    - b. Depths will be as indicated on the Drawings.
    - c. Refer to the geotechnical report for soil condition including fully saturated soil conditions.
- C. Manholes, grade rings, risers, and bases:
  - 1. Manhole:
    - a. Nominal sizes as indicated on the Drawings.
  - 2. Grade rings:
    - a. At least 1 but not more than 2 grade rings shall be used.
    - b. Maximum total distance from top of cone section to final grade: In accordance with Little Rock Water Reclamation Authority Standard Details.



3. Cone and riser sections:
    - a. As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
    - b. Cone sections shall be concentric.
  4. Manhole bases:

As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
- D. Threaded lifting inserts:
1. Design inserts to be fully threaded:
    - a. Do not fully penetrate through entire manhole wall.
  2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
  3. Design with minimum safety factor of 4.0.
  4. Do not use reinforcing steel bars.

## 2.03 MATERIALS

- A. Cast iron manhole frames and covers.
1. In accordance with ASTM A48 and Little Rock Water Reclamation Authority Standard Details.
  2. Covers: Bolted (Watertight) as specified.
  3. Concrete collars: As indicated on the Drawings.
- B. Manhole bases, risers, and grade rings:
1. Cement: Type II portland cement in accordance with ASTM C150.
  2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
  3. Sections: Steel reinforced.
  4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
  5. Top and bottom of sections: Parallel.
  6. In accordance with Little Rock Water Reclamation Authority Standard Details.
- C. Joint sealant:
1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
  2. Manufacturers: One of the following or equal.
    - a. Tylox Superseal.
    - b. Kent Seal - Hamilton Kent Corp.
- D. Exterior joint wrap:
1. Butyl based seal that is self-priming, self-sealing, and permanently flexible designed to create a high-performance seal in precast structures.
  2. Sealant shall provide a flexible watertight seal around perimeter of joint.
  3. Seal shall be highly resistant to temperature extremes and acid or caustic environments.
  4. Width = 6" minimum.
  5. Manufacturers: One of the following or equal.
    - a. Sealing Systems Inc. - Infi-Shield Gator Wrap.
    - b. Trelleborg – Bidco External Joint Wrap.



## 2.04 COMPONENTS

- A. Pipe stubs:
  - 1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
  - 2. Plugging stubs:
    - a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
    - b. Unless otherwise indicated on the Drawings, comply with following:
      - 1) Stubs up to and including 21 inches: Vitrified clay stoppers.
      - 2) Stubs greater than 21 inches: Brick plugs.
- B. Resilient pipe connectors:
  - 1. Unless otherwise indicated on the Drawings or specified, provide a flexible watertight compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
  - 2. Resilient pipe connectors:
    - a. Manufacturers: The following or equal.
      - 1) A-LOK Premium.
      - 2) NPC Kor-N-Seal.
- C. Threaded lifting inserts.
- D. Drop manholes:
  - 1. Construct drop manholes at locations and in accordance with details indicated on the Drawings in accordance with Little Rock Water Reclamation Authority Standard Details.
  - 2. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
  - 3. Furnish and set fittings as indicated on the Drawings.

## 2.05 IDENTIFICATION MARKINGS

- A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
  - 1. Date of manufacture of the item.
  - 2. Name or trademark of the manufacturer.
  - 3. Internal diameter in inches.
  - 4. Number of the manhole as indicated on the Drawings.

## 2.06 QUALITY CONTROL

- A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.
- B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the Owner or Owner's representative.
- C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
  - 1. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.



2. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe.
  - a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
  - b. Devices are subject to inspection by Engineer.
- D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.
- E. Remove rejected manholes immediately.

### **PART 3 EXECUTION**

#### **3.01 MANHOLE INSTALLATION**

- A. Excavate and backfill as specified in Section 02318 - Trenching and as indicated on the Drawings.
- B. Maintain identification markings on installed pieces throughout installation.
- C. Do not use sections with chips or cracks in the joint.
- D. Engineer may inspect manhole sections, prior to installation.
- E. Repair of manhole sections damaged during installation in accordance with manufacturer's repair procedures; with the concurrence of the Engineer.
- F. Install joint sealant material in accordance with manufacturer's instructions:
  1. Completed manhole: Rigid and watertight.
- G. Fill threaded lifting inserts with grout.
- H. Lay grade rings on joint sealant with sides plumb and tops level.
- I. Set frame and covers as specified and as indicated on the Drawings.
- J. Dampproofing is not required.

#### **3.02 CLEANING**

- A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.
- B. After completing each manhole, remove construction material debris from inside the manhole.

#### **3.03 FUNCTIONAL TESTING**

- A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.



- B. Vacuum testing in accordance with ASTM C1244.
1. Install the vacuum test head on top of the manhole.
    - a. Install and brace sealing devices on influent and effluent pipes.
  2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
  3. Compare test results with the minimum time requirements stated in the table below.
    - a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

<b><u>Minimum Elapsed Time, Minutes: Seconds</u></b>				
<b>Manhole Depth, ft.</b>	<b>Manhole Diameter, inches</b>			
	36	48	60	72
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:46	0:57
16	0:28	0:40	0:52	1:07
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:05	1:21
22	0:38	0:55	1:12	1:29
24	0:42	0:59	1:18	1:37
26	0:46	1:04	1:25	1:45
28	0:49	1:09	1:31	1:53
30	0:53	1:14	1:38	2:01

END OF SECTION



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## **SECTION 02621**

### **STABILIZATION FABRIC**

#### **PART 4 GENERAL**

##### **4.01 SUMMARY**

- A. Section includes: Woven stabilization fabric used for subgrade enhancement.

##### **4.02 REFERENCES**

- A. ASTM International (ASTM):
1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
  2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
  3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
  4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
  5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
  6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
  7. D4595 - Standard Test Method for Tensile Properties of Geotextiles by the wide strip method.

##### **4.03 DEFINITIONS**

- A. Stabilization fabric: Woven geotextile fabric manufactured from polypropylene yarns.

##### **4.04 SUBMITTALS**

- A. Product data.
- B. Samples.
- C. Quality control submittals:
1. Certificates of Compliance.
  2. Manufacturer's Installation Instructions.

##### **4.05 DELIVERY, STORAGE, AND HANDLING**

- A. Storage and protection:
1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.



#### 4.06 PROJECT CONDITIONS

- A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

### PART 5 PRODUCTS

#### 5.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 2x2HF.
  2. Ten Cate Geosynthetics, Mirafi HP270.

#### 5.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property <sup>(1)</sup>	Test Method	Unit	Requirements <sup>(1)</sup>
Grab Tensile Strength	ASTM D4595	lbs	2640
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	80
Apparent Opening Size (AOS)	ASTM D4751	US sieve	30
Permittivity	ASTM D4491	sec <sup>-1</sup>	0.06
Flow Rate	ASTM D4491	gpm/ft <sup>2</sup>	40
(1) Minimum average roll values.			

### PART 6 EXECUTION

#### 6.01 EXAMINATION

- A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

#### 6.02 PREPARATION

- A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

#### 6.03 INSTALLATION

- A. Follow manufacturer's installation instructions and as complimented in this Section.
- B. Place the stabilization fabric smoothly without folds or wrinkles.





- C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.
- E. Do not drag stabilization fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.
- G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

#### **6.04 FIELD QUALITY CONTROL**

- A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION



## **SECTION 02772**

### **CONCRETE CURBS, GUTTERS, AND SIDEWALKS**

#### **PART 22 GENERAL**

##### **22.01 SUMMARY**

- A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

##### **22.02 SYSTEM DESCRIPTION**

- A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

##### **22.03 SUBMITTALS**

- A. Product data: Submit data completely describing products.
- B. Samples: Submit samples when requested.

#### **PART 23 PRODUCTS**

##### **23.01 MATERIALS**

- A. Concrete: Class A, as specified in Section 03300 - Cast-In-Place Concrete.
- B. Curb finishing mortar: 1 part portland cement to 2 parts sand.
- C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.
- D. Joint materials:
  - 1. Expansion: As specified in Section 03150 - Concrete Accessories.

#### **PART 24 EXECUTION**

##### **24.01 EXAMINATION**

- A. Verification of Conditions:
  - 1. Verify field conditions, including subgrade condition and interferences, before beginning construction.



## 24.02 PREPARATION

- A. Surface preparation:
  - 1. Subgrade:
    - a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 02050 - Soils and Aggregates for Earthwork.
    - b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
  - 2. Forms and subgrade: Water immediately in advance of placing concrete.

## 24.03 INSTALLATION

- A. Special techniques:
  - 1. Contractor's option:
    - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
    - b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
    - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
    - d. Discontinue use of machines when results are not satisfactory to the Engineer.
- B. Forms:
  - 1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
  - 2. Thoroughly clean prior to each use and coat with form releasing material.
- C. Expansion and weakened-plane joints:
  - 1. Expansion joints:
    - a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
    - b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
    - c. Fill joints with expansion joint filler material.
  - 2. Weakened-plane joints:
    - a. Construct as indicated on the Drawings.
    - b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.
- D. Concrete:
  - 1. Placing:
    - a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
  - 2. Compacting:
    - a. Compact by mechanical vibrators accepted by the Engineer.
    - b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.



3. Form removal:
    - a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
    - b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
  4. Finishing and curing: Comply with requirements as specified in Section 03366 - Tooled Concrete Finishing except as modified here:
    - a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
    - b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
    - c. Edge concrete at expansion joints to 1/4 inch radius.
    - d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
    - e. Sidewalks and ramps: Broom finish
- E. Backfilling:
1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

#### **24.04 FIELD QUALITY CONTROL**

- A. Tests:
1. Curbs and gutters:
    - a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
    - b. Correct deviations in excess of 1/4 inch.
  2. Gutters:
    - a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
    - b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
    - c. Required results:
      - 1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
      - 2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

#### **24.05 ADJUSTING**

- A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.



- B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION

## SECTION 02939

### SEEDING

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## PART 7 GENERAL

### 7.01 SUMMARY

- A. Section includes seeding.



## 7.02 REFERENCES

- A. Association of Official Seed Analysts (AOSA).
- B. United States Department of Agriculture (USDA).
- C. United States Environment Protection Agency (EPA).

## 7.03 DEFINITIONS

- A. Duff layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B. Finish grade: Elevation of finished surface of planting soil.
- C. Manufactured topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F. Planting soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- H. Surface soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.
- I. Weeds:
  - 1. Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Russian Thistle, Leafy Spurge, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Weed, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

## 7.04 SUBMITTALS

- A. Product data: For each type of product indicated:
  - 1. Pesticides and herbicides: Include product label and manufacturer's application instructions specific to this Project.



2. Fertilizer and organic matter: Include product label and manufacturer's application instructions specific to this Project.
  3. Soil amendment: Analysis.
- B. Certification of grass seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
1. Certification and inspection as required by governmental authorities of each seed mixture. Include identification of source and name and telephone number of supplier.
- C. Qualification data: For qualified landscape Installer.
- D. Samples: Imported topsoil, organic matter, erosion control blanket and mulch.
- E. Product certificates: For soil amendments and fertilizers, from manufacturer.
- F. Maintenance instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

#### **7.05 QUALITY ASSURANCE**

- A. Installer qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
1. Professional membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
  2. Experience: 5 years' successful experience in the installation of seeded areas similar in size to this project.
  3. Installer's field supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  4. Personnel certifications: Installer's field supervisor shall have certification in all of the following categories from the Professional Landcare Network:
    - a. Certified Landscape Technician - Exterior, with installation and irrigation specialty area(s).
  5. Maintenance proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
  6. Pesticide applicator: State licensed, commercial.
- B. Soil-testing laboratory qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil. Refer to plan notes for number and location of soil analysis tests.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.



2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Engineer.
  - a. A minimum of 3 representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.
  - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated.
    - 1) State recommendations in weight per 1,000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
  - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Pre-installation conference: Conduct conference at project site.

#### **7.06 DELIVERY, STORAGE, AND HANDLING**

- A. Seed and other packaged materials:
  1. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
  2. Protect seed during delivery and storage.
  3. Seed that has become wet or otherwise damaged will not be acceptable.
- B. Deliver packaged materials in waterproof bags showing weight, chemical analysis and name or trademark of manufacturer.
  1. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, percentage of purity (PLS), percentage of germination and location of packaging.
- C. Local sourcing of seed not in sealed containers is permitted for smaller projects.
- D. Label seed bags per variety.
- E. Store materials in protected and covered storage until application or use.
- F. Bulk materials:
  1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.
- G. Truck receipts: For verification of all soil amendments and imported topsoil.
- H. Hydroseeding:
  1. Ensure that seed packages are packed to provide adequate protection against injury during transit.





2. Deliver undamaged sealed seed bags with legible labels showing weight, analysis, vendor's name and address, and point of origin.
  - a. Label seed bags per variety.
3. Deliver dry commercial process or packaging, such as fertilizer, in undisturbed original unopened containers with legible labels showing the manufacturer's guaranteed analysis or description.
4. Inspect materials and packages upon delivery.
  - a. Discard damaged packages or containers immediately.
5. Store materials in protected and covered storage until application or use.

#### **7.07 WARRANTY**

- A. Warranty:
  1. Guarantee all seeding to be alive and healthy for 1 years following date of final completion by the Engineer.
  2. Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
  3. All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
  4. The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
  5. Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
  6. Maximum single bare spot size of non-irrigated seed is 1 square foot.
  7. All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
- B. Replace seeding when it is no longer in a satisfactory condition or do not meet the preceding standard as determined by the Engineer or the duration of the Guarantee/Warranty Period.
  1. Make replacements as soon as possible within the recommended seeding schedule.
- C. Replacements:
  1. Seed of same mix, quality and species as originally specified, as soon as possible within the recommended seeding schedule, with a new 1-year warranty commencing on date of replacement.
  2. Repairs and replacements shall be made at no expense to the Owner.

### **PART 8 PRODUCTS**

#### **8.01 STAKES**

- A. Softwood lumber, chisel pointed.

#### **8.02 SOIL AMENDMENTS AND FERTILIZERS**

- A. Apply soil amendments and fertilizer as indicated on the Drawings.
- B. Submit soil amendment and fertilizer recommendations, along with supporting soil test analysis, for Engineer approval prior to application on the site.
- C. Fertilizer:



1. Uniform in composition, free flowing and suitable for application with approved equipment, of the proportions necessary to eliminate any deficiencies of topsoil, as indicated in analysis.
  2. Delivered to the site fully labeled according to applicable laws.
  3. Packaging: Display the name, tradename, trademark and warranty of the provider.
- D. Fertilizer grade description format:
1. Three sets of 2-digit numbers.
  2. Numbers represent the percent by weight of nutrients.
  3. First number is the amount of nitrogen (N).
  4. Second number is the amount of phosphate (P<sub>2</sub>O<sub>5</sub>).
  5. Third number is the amount of potash (K<sub>2</sub>O).
  6. Example: 10 10 10.

### **8.03 HERBICIDE AND PESTICIDE**

- A. Submit labels for Engineer approval.
- B. Pesticides:
1. Registered and approved by EPA.
  2. Acceptable to authorities having jurisdiction.
  3. Type recommended by manufacturer for each specific problem.
  4. As required for Project conditions and application.
  5. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- C. Pre-emergent herbicide (Selective and Non-Selective):
1. Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- D. Post-emergent herbicide (Selective and Non-Selective):
1. Effective for controlling weed growth that has already germinated.

### **8.04 WATER**

- A. Use potable water for making up seed mixture.
- B. Plant effluent may be used for hydroseeding watering and maintenance with Owner approval, as specified in this Section.

### **8.05 SOILS**

- A. Topsoil:
1. Fertile soil, typical for locality, capable of sustaining vigorous plant growth.
  2. Taken from drained site.
  3. Free of subsoil, stones more than 1 inch in diameter, clay clumps, or impurities, plants weeds and roots.
  4. Organic content:
    - a. Minimum 2 percent by mass.
  5. pH value:
    - a. Minimum: 5.5.
    - b. Maximum: 7.5.



## 8.06 SEED

- A. Provide seed as indicated on the Drawings.
- B. Packaging: Provide separate bags or containers for each variety of seed.
- C. Plant seed that is appropriate for planting season.
- D. Provide seed from tested lots and delivered to project site in standard containers labeled as required by U.S. Department of Agriculture regulations and applicable state regulations.
- E. Use labels that show variety of strain of seed, degree of purity (percent), rate of germination (percent), weed content (percent), and date of test.
- F. Lawn seed:
  - 1. Common name: Bermuda grass (*Cynodon Dactylon*).
  - 2. Planted from April 15 to July 15.
  - 3. Fancy hulled seed.
  - 4. Seed mixture:
    - a. Germination minimum: 88 percent.
    - b. Pure seed minimum: 94 percent.
    - c. Weed seed maximum: 0.35 percent.
- G. Grass seed:
  - 1. Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
  - 2. Species: Match existing grass type.
  - 3. Seed mixture:
    - a. Germination minimum: 95 percent.
    - b. Pure seed minimum: 85 percent.
    - c. Weed seed maximum: 0.5 percent.
    - d. Other than grass seed, non-viable seed, chaff, hulls, live seed of crop plants (other than those specified), harmless inert matter, and maximum: 18 percent.
  - 4. Proprietary seed mix: Western Native Seed near Salida, CO.
- H. Buffalo grass mix:
  - a. Common name: "Topgun" or "Texoka" seed.
  - b. Drill rate: 90 pounds of seed per acre (2 pounds 100 feet square).
  - c. Timing: April 1 - September 1.
  - d. Cannot be hydro-mulched.
    - 1) Areas susceptible to erosion: Cover drilled seeded area with hydro-mulched fiber.
- I. Wildflower seed:
  - 1. Wildflower seed mix from latest crop.
  - 2. Seed mixture:
    - a. Pure live seed content minimum: 80 percent.
  - 3. Seed testing maximum: 6 months from planting date.
    - a. Do not use seed mix after expiration date.
  - 4. Seeding rate:
    - a. *Lupinus luteus*: 8 pounds per acre.



- b. Eschscholtzia Californica: 1.9 pounds per acre.
- c. Gazania Splendeus: 12 pounds per acre.
- d. Clarkia Amoena: 4.5 pounds per acre.
- e. Lasthenia Glabrata: 4 pounds per acre.
- f. Achillea Borealis: 3 pounds per acre.
- g. Stipa Pulchrum: 3 pounds per acre.
- h. Gilia Capitata: 6 pounds per acre.
- i. Festuca Idahoeasis: 4 pounds per acre.

- J. Erosion control seed:
  - 1. Erosion control seed mix from latest crop.
  - 2. Seed mixture:
  - 3. Pure live seed content minimum: 80 percent.
  - 4. Seed testing maximum: 6 months from planting date.
    - a. Do not use seed mix after expiration date.
  - 5. Seeding rate:
    - a. Blando Brome: 20 pounds per acre.
    - b. Annual Rye: 25 pounds per acre.
    - c. Rose Clover: 20 pounds per acre.
    - d. Zorro Annual Fescue: 10 pounds per acre.

#### 8.07 MULCHES

- A. As indicated on the Drawings.
- B. Straw mulch:
  - 1. Oats, barley, wheat or rye only.
  - 2. Free from weeds, foreign matter detrimental to plant life, and dry.
  - 3. Minimum length 10 inches long: 50 percent of straw.
  - 4. Not acceptable:
    - a. Hay or chopped cornstalks.
    - b. Old straw mulch which breaks during crimping.
    - c. Straw in such an advanced stage of decomposition as to smother or retard the normal growth of grass.
- C. Wood cellulose fiber mulch:
  - 1. Wood fibers must be capable of being evenly dispersed and suspended when agitated in water.
  - 2. Furnish with a biodegradable green dye to allow visual metering of its application.
  - 3. Not acceptable:
    - a. Substance or factor which might inhibit germination or growth of grass seed, with organic tacifier.

#### 8.08 HYDRO-MULCH

- A. Hydro-mulch seed:
  - 1. Seeding:
    - a. Mixture:
      - 1) Ratio of wood cellulose fiber, seeds and fertilizer: 4:1:6 mixture.
        - a) Fiber: 20 pounds.
        - b) Seeds: 5 pounds.
      - (1) Modify mixture according to the planting season as follows:



- (a) February through August: 20 pounds of hulled common Bermuda grass per acre.
      - (b) August through February: combination of 15 pounds of unhulled common Bermuda and 15 pounds of unhulled Gulf Coast Annual Rye seed per acre.
      - c) Fertilizer: 30 pounds.
    - 2) Coverage: 1,000 square feet.
  - b. Provide a recommendation for proposed mixture based on time of year hydro-mulch is actually performed.
- B. Hydro-mulching equipment:
  - 1. Manufacturers: One of the following or equal:
    - a. Bowie Industries, Inc.
    - b. Reinco.
    - c. Finn Equipment Co.
  - 2. Equipment requirements:
    - a. Built-in agitation system sufficient to agitate, suspend, and homogeneously mix slurry containing fiber, fertilizers, chemicals, and seed mix.
    - b. Capable of slurry distribution line large enough to prevent stoppage.
    - c. Equipped with set of hydraulic spray nozzles which provide continuous non-fluctuating discharge of minimum 225 pounds per square inch at end of spray nozzle.

#### 8.09 HYDROSEEDING MATERIALS

- A. Seed mix:
  - 1. Manufacturers: One of the following or equal:
    - a. Grass Growers.
    - b. Conwed Corp.
    - c. Eva Cell Co.
  - 2. Seed mix from the latest crop.
  - 3. Minimum pure live seed content to be 80 percent, and tested within the preceding 6 months.
  - 4. Do not use seed mix after expiration date:
    - a. Blando Brome: 20 pounds per acre.
    - b. Annual Rye: 25 pounds per acre.
    - c. Rose Clover: 20 pounds per acre.
    - d. Zorro Annual Fescue: 10 pounds per acre.
- B. Mulch:
  - 1. Wood fiber manufactured for hydroseeding: Fiber mulch:
  - 2. Manufacturers: One of the following or equal:
    - a. Grass Growers.
    - b. Conwed Corp., Fibers Div.
    - c. Eva Cell Co.
- C. Water:
  - 1. Use potable water for making up seed mixture.
  - 2. Plant effluent may be used for hydroseed watering with Owner approval as specified in this Section.



- D. Granular fertilizers:
  - 1. Manufacturers: One of the following or equal:
    - a. Sierra Chemical Co.
    - b. Green Light Co., Wonder Grow Chemicals.
    - c. Kay-Fries Chemicals.
  - 2. Fertilizer grade: 16-20-0.

#### **8.10 EROSION CONTROL BLANKETS**

- A. As indicated on the Drawings.
- B. Erosion control blanket:
  - 1. Manufacturer: The following or equal:
    - a. American Excelsior Company, Curlex®.
  - 2. Jute matting, open weave.
  - 3. Regular blanket, machine produced mat of curled wood excelsior of 80 percent 6 inch or longer fiber length with a consistent width of fibers evenly distributed throughout mat.
  - 4. Photo-biodegradable extruded plastic netting cover the top side of blanket.
  - 5. Secure netting to wood excelsior by extra heavy lines of plastic woven into the width of each blanket.
  - 6. Smolder resistant with no chemical additives.

### **PART 9 EXECUTION**

#### **9.01 EXAMINATION**

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
  - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
  - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 4. Uniformly moisten excessively dry soil that is not workable, and which is too dusty.
- B. Start of work covered in this Section constitutes Contractor's approval of all existing site conditions.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by the Engineer and replace with new planting soil.



## 9.02 SITE CONDITIONS

- A. Planting restrictions: Plant during 1 of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date.
  - 1. Irrigated seed areas: Seed from ground thaw to July 31 and September 1 to October 15.
  - 2. Non-irrigated seed areas: Seed from March 15 to July 4 and September 1 to October 15.
  - 3. Pure Warm Season Grass Seed Areas: Seed from June 1 to August 15.
  - 4. Dormant Seeding Areas: Seed from October 15 to ground freeze.
  - 5. Per seed detail.
- B. Coordinate with Contractor's work requiring access to site over existing vegetation areas.
  - 1. No trucking or moving of equipment or materials shall be permitted over completed seed areas.
- C. Coordinate with installation of all underground system piping and outlets.
- D. Weather limitations:
  - 1. Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained.
  - 2. Apply products during favorable weather conditions according to manufacturer's written instructions.

## 9.03 EXISTING VEGETATION RENOVATION

- A. Renovate existing vegetation.
- B. Renovate existing vegetation damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  - 1. Reestablish vegetation where settlement or washouts occur or where minor regrading is required.
  - 2. Install topsoil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory vegetation areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing vegetation.
- F. Prior to seeding, irrigate for a minimum of 2 weeks to allow germination of weed seeds.
  - 1. Apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.
  - 2. Do not spray on a day when wind is detectable.
  - 3. Remove remaining vegetative matter.
  - 4. Repeat irrigation and herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.



- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil.
  - 1. Install new planting soil to fill low spots and meet finish grades.
- J. Apply seed and protect with hydro mulch as required for new vegetation.
- K. Water newly planted areas and keep moist until new turf is established.

#### **9.04 PREPARATION**

- A. Protect existing and new structures, fences, utilities, sidewalks, paving, curbs, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
  - 1. Protect adjacent and adjoining areas from hydromulching overspray.
  - 2. Protect grade stakes set by others until directed to remove them.
  - 3. Protect landscaping and other features remaining as final work.
- B. Limit turf subgrade preparation to areas to be planted.
- C. Newly graded subgrades:
  - 1. Loosen/scarify subgrade to a minimum depth of 6 inches.
  - 2. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
  - 3. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted the subgrade.
  - 4. Tolerances: Top of subgrade plus or minus 1 inch.
- D. Prepare subgrade and eliminate uneven areas and low spots.
  - 1. Maintain lines, levels, profiles and contours.
  - 2. Make changes in grade gradual. Blend slopes into level areas.
- E. Do not prepare subgrade in areas of on-site plant preservation.
- F. Do not bury foreign material beneath areas to be seeded.
- G. Remove any contaminated subgrade.
  - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
    - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    - b. Mix lime with dry soil before mixing fertilizer.
  - 2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
    - a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
    - b. Reduce elevation of planting soil to allow for soil thickness of sod.





- H. Unchanged subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
  - 1. Remove existing grass, vegetation, and turf.
    - a. Do not mix into surface soil.
  - 2. Loosen surface soil to a depth of at least 6 inches.
    - a. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil.
    - b. Apply superphosphate fertilizer directly to surface soil before loosening.
  - 3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
  - 4. Legally dispose of waste material, including contaminated soils, grass, vegetation, and turf, off Owner's property.
- I. Finish grading:
  - 1. Grade seeding areas to a smooth, uniform surface plane with loose, uniformly fine texture.
  - 2. Grade to within plus or minus 1/2 inch of finish elevation.
  - 3. Roll and rake, remove ridges, fill depressions to meet finish grades, and ensure positive surface drainage.
  - 4. Maintain profiles and contour of subgrade.
  - 5. Limit finish grading to areas that can be planted in the immediate future.
- J. Rip topsoil that has been spread to a minimum depth of 8 inches in one direction using an agricultural ripper with tines spaced at no greater than 18 inches.
  - 1. Areas adjacent to walks, structures, curbs, etc., where the use of large mechanical equipment is difficult, shall be worked with smaller equipment or by hand.
- K. Manually spread topsoil close to plant materials and structures to prevent damage.
- L. Spread amendments, as determined by the soil test results or indicated on the Drawings, over the entire area to be seeded and incorporate into the top 6 inches of soil by disking or rototilling until a uniform mixture is obtained with no pockets of soil or amendments remaining.
- M. Restore fine grade with float drag to remove irregularities resulting from tilling operations.
  - 1. Float drag or rake in 2 directions.
  - 2. Remove any additional stones over 1 inch that have come to the surface.
  - 3. Perform drainage test by applying water with the irrigation system.
  - 4. Do not plant until the finished grade is reviewed by the Engineer.
  - 5. This review does not reduce Contractor's responsibility to provide a finished product that drains.
- N. Apply fertilizer, if necessary, after smooth raking of topsoil and prior to planting of seed.
  - 1. Apply fertilizer at a rate as determined by the soil tests or indicated on the Drawings.
  - 2. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
  - 3. Mix thoroughly into upper 6 to 8 inches of soil.



- O. Lightly water to aid the dissipation of fertilizer.
- P. Remove any additional stones over 1 inch that have come to the surface.
- Q. Moisten prepared area before planting if soil is dry.
  - 1. Water thoroughly and allow surface to dry before planting.
  - 2. Do not create muddy soil.
- R. Before planting, obtain Engineer's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- S. Tolerances: Top of topsoil plus or minus 1/2 inch.

#### **9.05 PESTICIDE APPLICATION**

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations.
  - 1. Coordinate applications with Owner's operations and others in proximity to the Work.
  - 2. Notify Owner before each application is performed.
- B. Post-emergent herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

#### **9.06 SEED**

- A. Preparation for seeding:
  - 1. Prior to seeding, if weeds exist, apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.
  - 2. Do not spray on a day when wind is detectable.
  - 3. Remove remaining vegetative matter.
  - 4. Repeat herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.
- B. Drill seeding:
  - 1. Drill seed by means of a Brillion mechanical power-drawn drill seeders, or equal, to a maximum depth of 1/4-inch followed by packer wheels or drag chains to provide smooth finish.
  - 2. Seed at the rates given below.
  - 3. Seed in 2 passes at right angles to one another.
  - 4. Sow half the seed in each pass.
  - 5. Provide markers or other means to ensure that the successive seeded strips will overlap or be separated by a space no greater than the space between the rows planted by the equipment being used.
  - 6. Do not seed during windy weather.
  - 7. Restore fine grade after seeding as requested by the Engineer.
  - 8. Remove irregularities by hand raking or rolling.
  - 9. In areas inaccessible to a drill seeder, broadcast seed by hand in 2 opposite directions.
    - a. Rake in seed after broadcasting.



- b. Do not broadcast seed during windy weather.
- 10. Seeding rates:
  - a. Seeding rates shall be as recommended by the seed supplier for drill seeded areas.
  - b. Hand and broadcast seeded areas shall receive 2 times the seeding rate indicated.
- 11. Do not seed areas in excess of that which can be mulched on same day.
- 12. Do not sow immediately following rain, when ground is too dry, frozen, or during windy periods.
- 13. Roll seeded area with roller not exceeding 100 pounds.
- 14. Immediately following seeding and compacting, apply mulch.
- 15. Sow seed with spreader or seed drill machine.
  - a. Do not broadcast or drop seed when wind velocity exceeds 5 miles per hour.
  - b. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
    - 1) Do not use wet seed or seed that is moldy or otherwise damaged.
    - 2) Do not seed against existing trees.
      - a) Limit extent of seed to outside edge of planting saucer.
- 16. Sow seed at a total rate as recommended by the seed supplier.
- 17. For any Broadcast seeded areas rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- 18. Protect seeded areas with erosion-control mats where indicated on the Drawings; install and anchor according to manufacturer's written instructions.
- 19. In final preparations for seeding, use level board not less than 8 feet in length to ensure true and accurate grades.
- 20. Finish grade lawn areas to 2 inches below elevation of adjacent paving.
- 21. Do not take heavy objects, except lawn rollers, over areas that have been prepared for seeding.
- 22. Prior to seeding, Engineer shall accept areas for grade and compaction.
- C. Seed establishment on slopes:
  - 1. Protect seeded areas with slopes and swales exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
  - 2. Roll fabric onto slopes without stretching or pulling.
  - 3. Lay fabric smoothly on surface in direction of water flow.
  - 4. Bury top end of each section in 6-inch deep excavated topsoil trench.
  - 5. Provide 6-inch overlap of adjacent rolls.
  - 6. Backfill trench and rake smooth, level with adjacent soil.
  - 7. Secure outside edges and overlaps at 24-inch intervals with stakes.
  - 8. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
  - 9. For sides of ditches, lay fabric laps in direction of water flow.
  - 10. Lap ends and edges minimum 6 inches.
- D. Satisfactory seed areas:
  - 1. Turf installations shall meet the following criteria as determined by the Engineer:
  - 2. Acceptance for soil preparation (topsoil installation) and final grading shall be given by the Engineer upon satisfactory completion of each section or area prior to seeding.



3. Final completion for seeded areas shall be given by the Engineer as soon as there is an even stand of grass with germination over 100 percent of the site.
    - a. Warranty:
      - 1) Guarantee all seeding to be alive and healthy for 2 years following date of final completion by the Engineer.
      - 2) Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
      - 3) All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
      - 4) The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
      - 5) Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
      - 6) Maximum single bare spot size of non-irrigated seed is 1 square foot.
      - 7) All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
    - b. Re-seed areas that in the opinion of the Engineer do not meet the preceding standards.
  4. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.
- E. Seeded area maintenance:
1. Maintain and establish seeded area by watering, noxious weed management, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable seeded area.
  2. Roll, regrade, and replant bare or eroded areas and remulch.
  3. Provide materials and installation the same as those used in the original installation.
    - a. Fill in as necessary soil subsidence that may occur because of settling or other processes.
      - 1) Replace materials and seeded area damaged or lost in areas of subsidence.
    - b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
    - c. Apply treatments as required to keep seeded area and soil free of pests and pathogens or disease.
      - 1) Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
  4. Watering: Install and maintain temporary piping, hoses, and seeded area watering equipment to convey water from sources and to keep meadow uniformly moist.
  5. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch.
    - a. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
  6. Water meadow with fine spray at a minimum rate of 1/2 inch per week or more for seed establishment for 6 weeks after planting or until seed establishment is determined by the Engineer (whichever is longer) unless rainfall precipitation is adequate.



## 9.07 MULCH

- A. Straw mulching:
  - 1. After seeding, apply 2 tons of small grained straw per acre.
    - a. Spread straw to give a 1/2 inch to 1 inch thick layer of mulch (3 to 5 straws thick) and crimp in 2 to 3 inches with a mechanical crimper or other approved equipment.
  - 2. Hand crimping shall be employed in areas inaccessible to crimper, or where excessive slopes would cause unsatisfactory results.
  - 3. Crimping against the contour shall not be accepted.
  - 4. Apply water and tackifier with a fine spray immediately after each area has been mulched.
    - a. Saturate to 4 inches of soil.

## 9.08 HYDRO-MULCH

- A. Hydro-mulching:
  - 1. Hydro-mulch all dormant seeded areas with a slurry mix containing additional tacifier.
  - 2. Utilize hydraulic equipment with nozzle adapted for hydraulic mulching with storage tanks having means of estimating volume used or remaining in the tank.
  - 3. Hydro-mulch shall consist of tacifier applied at a rate of 100 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
    - a. Hydro-mulch applied to dormant seeded areas shall consist of tacifier applied at a rate of 150 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
  - 4. Protect seeded areas with slopes not exceeding 1:4 by spreading straw mulch.
    - a. Spread uniformly at a minimum rate of 2 tons per acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas.
    - b. Spread by hand, blower, or other suitable equipment.
      - 1) Anchor straw mulch by crimping into soil with suitable mechanical equipment.
      - 2) Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gallons per 1,000 square feet.
        - a) Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas.
        - b) Immediately clean damaged or stained areas.
  - 5. Protect seeded areas from hot, dry weather or drying winds by applying hydro mulch and tackifier within 24 hours after completing seeding operations.
    - a. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch and roll surface smooth.

## 9.09 HYDROSEED

- A. Installation:
  - 1. Surface preparation:
    - a. Area to be hydroseeded to be weed free and have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of 2 to 4 inches.



- b. Do not use any implements that will create an excessive amount of downward movement or clods on sloping areas.
      - c. Hydroseed bed may be prepared at time of completion of earth-moving work.
    - 2. Application:
      - a. Mark test plots to calibrate equipment and rate of vehicle.
        - 1) Continue test operations until satisfied with performance of even, smooth application.
      - b. Apply seed with wood cellulose fiber at 500 pounds per acre.
        - 1) Do not allow seed to stay within slurry longer than 30 minutes.
      - c. Immediately after seeding, apply wood fiber mulch at 3,000 pounds per acre with a tackifier adhesive at 75 pounds per acre.
        - 1) Mixture to be sufficient green in color to determine coverage.
        - 2) Use nontoxic dye that is water-soluble.
      - d. Foot traffic on hydroseed is not permitted.
    - 3. Slurry preparation:
      - a. Prepare slurry at project site, using potable water.
        - 1) Plant effluent is acceptable.
      - b. Dispose of any slurry that has not been used within 2 hours at a location off-site at Contractor's expense.
- B. Hydroseed watering:
  - 1. Provide temporary watering system or apply water with a water truck acceptable to Engineer.
    - a. Plant effluent may be used for hydroseed watering.
    - b. Do not place irrigation lines on top of embankment slope.
  - 2. Germination stage:
    - a. Initiate watering sequence within 24 hours after hydro-mulching planted areas. Leave water on long enough to moisten soil thoroughly to a depth of the fiber, taking care not to supersaturate or wash fiber or soil particles off the slopes. Observe irrigation system continually while in operation.
    - b. Contractor to repair all seed washing or erosion immediately.
    - c. Irrigate fiber and seed lightly and frequently to maintain optimum moisture content for maximum germination. Determine irrigation sequence according to air temperature, prevailing wind velocity, soil texture, orientation, and other logistical problems.
    - d. Keep soil moist at all times during germination period. Continue irrigation sequence until seedlings have grown beyond the germination stage, approximately 30 to 60 days.
- C. Establishment stage:
  - 1. Reduce watering frequency while increasing duration of the water sufficiently to allow for maximum water penetration for the expanding root system. Take care not to cause erosion.
  - 2. Precise watering reduction program to be determined by Contractor.
  - 3. Hardening-off stage:
    - a. Reduce irrigation frequency while increasing the duration of each water cycle.
    - b. A specific watering program to be approved by Owner.
- D. Hydroseed fertilizer:



1. Distributed uniformly over seed bed and incorporated into the soil. Incorporation may be part of the seed bed preparation or as part of the seeding operation, unless seed is broadcast.
    - a. If fertilizing is a part of the seed bed preparation, do not fertilize more than 15 days prior to seeding.
  2. Apply fertilizer at 250 pounds per acre.
- E. Hydroseed mowing:
1. Contractor to mow seeded areas prior to spring germination.
- F. Hydroseed maintenance:
1. Maintain hydroseed areas for 1 year following final acceptance.
  2. Maintenance involves watering, mowing, and any other activities required to establish and maintain the ground cover.

#### **9.10 EROSION CONTROL BLANKETS**

- A. Preparation for erosion-control materials:
1. Install erosion-control materials in accordance with manufacturers recommendations.
  2. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions.
    - a. Fasten as recommended by material manufacturer.
  3. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
  4. Erosion control hydroseeding to be applied to all stormwater ditches, stormwater pipe inlets, stormwater pipe outlets, and as indicated on the Drawings.
    - a. Hydroseeding shall be the last activity conducted by Contractor prior to project acceptance.
  5. Moisten prepared area before planting if surface is dry.
  6. Water thoroughly and allow surface to dry before planting.
  7. Do not create muddy soil.

#### **9.11 CLEANUP AND PROTECTION**

- A. Promptly remove soil and debris created by turf work from paved areas.
1. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly seeded areas from traffic.
1. Maintain fencing and barricades throughout initial seed establishment.
- C. Remove nondegradable erosion-control measures after grass establishment period.
- D. During landscape installation:
1. All areas shall be reasonably clean at the end of each workday.
  2. Sidewalks and other paved areas shall be swept or washed down as needed.
- E. Project completion:



1. All debris, soil, and trash resulting from landscape operations shall be removed from the site.
2. All paved areas shall be washed down.

END OF SECTION





## **SECTION 02200**

### **SITE CLEARING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Clearing, grubbing, and stripping project site.

##### **1.02 REFERENCES**

##### **1.03 DEFINITIONS**

- A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.
- B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.
- C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the Engineer.

##### **1.04 QUALITY ASSURANCE**

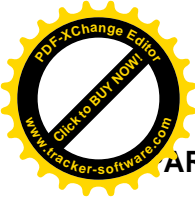
- A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.
- B. Pre-construction conference: Meet with Engineer to discuss order and method of work.

##### **1.05 PROJECT CONDITIONS**

- A. Environmental requirements:
  - 1. For suspected hazardous materials found: As specified in Section 01354 - Hazardous Material Procedures.

##### **1.06 SEQUENCING AND SCHEDULING**

- A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.



## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine site and verify existing conditions for beginning work.

### **3.02 PREPARATION**

- A. Protect existing improvements from damage by site preparation work.

### **3.03 INSTALLATION**

- A. Clearing:
  - 1. Clear areas where construction is to be performed and other areas as indicated on the Drawings, or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
  - 2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
  - 3. Contractor's temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.
- B. Grubbing:
  - 1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
  - 2. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.
- C. Stripping:
  - 1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
  - 2. Replace topsoil in areas disturbed during construction.

END OF SECTION



## SECTION 02240

### DEWATERING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Installation and maintenance of dewatering systems.
  - 2. Disposal of water entering excavation or other parts of the work.

##### 1.02 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
  - 2. Dewatering design analysis. Include the following:
    - a. Evaluation of anticipated subsurface conditions.
    - b. Required well spacing.
    - c. Diameter of wells.
    - d. Depth to screen, screen height, and mesh size.
    - e. Backfill and filter pack.
    - f. Pump size.
    - g. Drawdown duration.
    - h. Drawdown and steady state flow rates.
    - i. Plans for de-silting of groundwater before discharge.
    - j. Expected settlements.
  - 3. Include water drawdown curves in dewatering calculations.
  - 4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.
  - 5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
  - 6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to finished grade.
  - 7. Provide standby power to ensure continuous dewatering in case of power failure.
- B. Dewatering shored excavations:
  - 1. Dewater from within shoring.
  - 2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
  - 3. Extend impermeable shoring below bottom of excavation sufficient amount to:
    - a. Minimize lowering of groundwater outside shoring.
    - b. Prevent unstable excavation due to piping and heave.



4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.
  5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.
- C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.
- D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.
- E. Discharge:
1. Discharge to storm drain manholes or storm drain inlets will be permitted.

### **1.03 SUBMITTALS**

- A. Dewatering plan:
1. Dewatering design analysis.
  2. Required permits.
  3. Arrangement, location, and depths of dewatering system components.
  4. Type and sizes of filters.
  5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location. For pipes discharging to manholes, provide details of pipe entry at manhole.
- B. Well construction logs. Include:
1. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
  2. Construction details.
  3. Well development procedures and results.
  4. Deviations from original design.
- C. Qualifications:
1. Dewatering contractor.
  2. Dewatering design engineer.
  3. Testing laboratory.

### **1.04 QUALITY ASSURANCE**

- A. Dewatering plan and dewatering system analysis:
1. Prepared by a qualified Civil Engineer, licensed in the state where the Project is located.
    - a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.
- B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.
- C. Testing laboratory shall meet discharge permit testing laboratory qualifications.
- D. Regulatory requirements:
1. Obtain required water discharge permits.



## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.
- B. Keep excavations reasonably free of water.
- C. Make provisions to maintain continuous dewatering:
  - 1. Provide standby power to maintain dewatering during power outages and interruptions.
  - 2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.
- D. Intercept and divert precipitation and surface water away from excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.
- E. Disposal of water:
  - 1. Dispose of water from the work in suitable manner without damage to adjacent property.
  - 2. Do not drain water into work built or under construction.
  - 3. Dispose of water in such manner that it will not be a menace to public health or safety.
- F. Wells, well points, and drain lines for dewatering:
  - 1. Provide after receiving Engineer's written acceptance.
  - 2. Fill dewatering wells, pipes, and french drains to be left in place within structure foundation limits with Class "C" concrete as specified in Section 03300 - Cast-in-Place Concrete or grout as specified in Section 03600 - Grouting.

### **3.02 CONSTRUCTION**

- A. Prior to release of groundwater to its static level: Confirm that:
  - 1. All groundwater pressure relief devices for structure are fully operational.
  - 2. Construction of structure is complete and concrete has reached its specified compressive strength.
  - 3. Backfill of structure is complete.
- B. Control release of groundwater to its static level to prevent disturbance of natural foundation soils or compacted backfills and fills and to prevent flotation or movement of structures, pipelines, or other facilities.

END OF SECTION





## SECTION 02260

### EXCAVATION SUPPORT AND PROTECTION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

##### 1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
  - 1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

##### 1.03 DEFINITIONS

- A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
- B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.
- C. Support levels: Level of tiebacks, wales, rackers, bottom of excavation, and other types of support.

##### 1.04 SYSTEM DESCRIPTION

- A. Where General Engineering Design Practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
  - 1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
  - 2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.
- B. Design requirements:
  - 1. General:
    - a. For trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in.
      - 1) Perform design pursuant to general engineering design practice.
    - b. Dewatering:
      - 1) Dewater soil inside shoring as specified in Section 02240 - Dewatering for Structures.
      - 2) Do not lower groundwater outside of shoring more than 1 foot.
      - 3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.



- c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
- d. Minimum safety factor used for design shall not be less than 1.5.
- e. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
- f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
- g. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
- h. Generally acceptable references for design of shoring and excavations are as follows:
  - 1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
  - 2) Caltrans California Trenching and Shoring Manual.
  - 3) NAVFAC Design Manual 7.2.
  - 4) NAVFAC Design Manual 7.3.
  - 5) USS Steel Sheet Piling Design Manual.
- 2. Soldier piles and lagging:
  - a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
  - b. Provide full face lagging all around penetrations through lagging.
  - c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section 02312 - Controlled Low Strength Material (CLSM) after soldier piles are installed.
  - d. Assumed effective width for passive soil resistance:
    - 1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
    - 2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
    - 3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
  - e. Fill voids behind lagging with gravel or other material acceptable to Engineer.
  - f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
    - 1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
    - 2) Do not eccentrically load structural section of soldier piles or wales.
  - g. Design soldier piles for downward loads including vertical loads from tieback anchors.
- 3. Soil anchors, rock anchors, and deadman anchors:
  - a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
  - b. Proof load all production anchors to 125 percent of calculated load from shoring.
  - c. Lock off production anchors at calculated load from shoring.





- d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
  - e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
  - f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.
4. Set inside face of shoring back from structure not less than greater of following:
- a. 5 feet from face of wall.
  - b. 2 foot 6 inches from edge of foundation.
  - c. Depth of excavation below bottom of foundation.

C. Performance requirements:

1. General:
- a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
  - b. Specified provisions:
    - 1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
    - 2) Represent minimum requirement for:
      - a) Number and types of means needed to maintain soil stability.
      - b) Strength of such required means.
      - c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
3. Provide support for trench excavations for protection of workers from hazard of caving ground.
4. Provide shoring:
- a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
    - 1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
    - 2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
  - b. For trenches 5 feet and deeper.
  - c. For trenches less than 5 feet in depth, when there is potential for cave-in.
  - d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
- a. Using stiff shoring systems.



- b. Following appropriate construction sequence.
- c. Using shoring system that is tight enough to prevent soil loss through the shoring.
- d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
- e. Design for safety factor of not less than 1.50.
- f. Providing surface runoff routing and discharge away from excavations.
- g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
- h. Where sheet piling is used, use interlocking type sheets:
  - 1) Sheet piles shall be continuous and driven in interlock.
  - 2) If bottom of the excavation is located below the water table, use "ball and socket" or "thumb and finger" type interlock.
- i. Not applying shoring loads to existing structures and other improvements.
- j. Not changing existing soil loading on existing structures and other improvements.
- k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds **1/2** inch before wales are loaded.

## **1.05 SUBMITTALS**

- A. Shop drawings and calculations:
  - 1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
  - 2. Sketches showing the condition at various stages of installation and removal of shoring.
  - 3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
  - 4. When utilities penetrate shoring, show location of penetrations on elevation of all sides of shoring.
  - 5. Show details for ground support and sealing around utility penetrations.
  - 6. Indicate method used for installing driven shoring.
- B. Control points and schedule of measurements:
  - 1. Submit location and details of control points and method and schedule of measurements.
  - 2. Survey data.
- C. Detailed sequence of installation and removal of shoring:
  - 1. Consider effects of ground settlement in sequence of installation and removal of shoring.
  - 2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.
- D. Submit submittals for excavation support and protection as complete package and include all items required in this Section:
  - 1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.



- E. Submit dewatering submittals as specified in Section 02240 - Dewatering for Structures with submittals for excavation support and protection.

## **1.06 SEQUENCING**

- A. Do not begin construction of any shoring or excavation operations until:
  - 1. Submittals for shoring and dewatering have been accepted.
  - 2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
  - 3. Materials necessary for installation are on site.
- B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 CONSTRUCTION**

- A. Installation of shoring:
  - 1. Install means for providing safe and stable excavations as indicated in submittals.
- B. Removal of shoring:
  - 1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of Work.
  - 2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
  - 3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
    - a. Inject grout starting at bottom of void and progressively fill void to grade.
    - b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
  - 4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.
- C. Control points:
  - 1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
    - a. Set control points on shoring support system:
      - 1) Set points at distances not exceeding 25 feet at each support level.
  - 2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.



3. Perform horizontal and vertical survey and measurement of control points at least once every week:
    - a. Field notes shall show current measurement and change in measurement from first measurement taken.
  4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
- D. Maintenance:
1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
  2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION



## SECTION 02300

### EARTHWORK

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
  - 2. Backfilling and compacting under and around structures.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN m/m<sup>3</sup>)).
  - 3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

##### 1.03 DEFINITIONS

- A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.
- B. Embankments: Dikes, levees, berms, and similar facilities.
- C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

##### 1.04 SYSTEM DESCRIPTION

- A. Performance requirements:
  - 1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
  - 2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
  - 3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.



1.05

## **SUBMITTALS**

- A. Copy of Property Owner's Agreement allowing placement of surplus soil material on their property.
- B. Excavation plan.
- C. Testing lab: Submit Contractor's proposed testing laboratory capabilities and equipment.
- D. Test reports:
  - 1. Submit certified test reports of all tests specified to be performed by the Contractor.
  - 2. Sign and seal test reports by a registered Civil Engineer who practices geotechnical engineering registered in the state where the project is located.

## **1.06 QUALITY ASSURANCE**

- A. Initial compaction demonstration:
  - 1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
    - a. 50 cubic yards of backfill adjacent to structures.
    - b. 100 cubic yards of embankment work.
    - c. 100 cubic yards of fill.
    - d. 50 cubic yards of roadway base material.
    - e. 100 cubic yards of road fill.
  - 2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
  - 3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."
- B. Contractor shall perform all work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP) and as specified in Section 01355A – Stormwater Pollution Prevention Construction Activities: Best Management Practices.

## **1.07 SEQUENCING AND SCHEDULING**

- A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.
- B. If necessary, stockpile excavated material in order to use it at specified locations.
- C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.



## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Water for compacting: Use water from source acceptable to Engineer.
- B. Soil and rock materials:
  - 1. General:
    - a. Provide aggregate base course, controlled low-strength material, granular fill material native material, and sand where specified or indicated on the Drawings.
    - b. If suitable surplus materials are available, obtain native material from cut sections or excavations.
  - 2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 3. Granular fill material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 4. Native material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
  - 5. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Materials (CLSM).
- D. Geotextile fabrics:
  - 1. Stabilization fabric: As specified in Section 02620 – Stabilization Fabric.
  - 2. Stabilization fabric shall be used under backfill at concrete structures and pavement, under aggregate base course at paved areas, and under aggregate base course at gravel surfaced areas.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions:
  - 1. Character and quantity of material:
    - a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
    - b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
    - c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
    - d. Include wasting of excess material, if required, in cost of work to be performed.

### **3.02 PREPARATION**

- A. Backfills:
  - 1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts,



- hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompect scarified areas to density specified before placing backfill material or concrete.
  - 3. Do not place backfill against walls until:
    - a. Walls have been cast full height of structure and concrete has reached the specified strength.
    - b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
  - 4. Prior to backfilling:
    - a. Remove all forms.
    - b. Clean all trash and debris from the excavation site.
  - 5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.
- B. Fills:
- 1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompect scarified areas to density specified for compacted fills before placing of fill material or concrete.
- C. Roadway fills:
- 1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
  - 2. Recompect scarified areas to density specified for roadway fills before placing of roadway fill material.

### **3.03 INSTALLATION**

- A. General:
- 1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
  - 2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
  - 3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
  - 4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.
- B. Borrow area: There is no borrow area on Project site.
- 1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.
  - 2. There will be no additional cost to the Owner for use of imported material.





C. Compaction:

1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1557, or with ASTM D6938.
4. Maximum density obtained in laboratory when tested in accordance with ASTM D1557.
5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed H-20 loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
6. Compact to percentage of maximum density as follows:
  - a. Backfill adjacent to structures: 95 percent.
  - b. Backfilling voids: 95 percent.
  - c. Other areas: 85 percent.
  - d. Under present and future structures: 95 percent.
  - e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
  - f. Upper 6 inches of cuts: 95 percent.
  - g. Fills: 95 percent.

D. Dewatering: As specified in Section 02240 - Dewatering.

E. Excavation:

1. Blasting: Not permitted.
2. Excavations for structures:
  - a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure, including trenching for piping and all work incidental thereto.
  - b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
  - c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
  - d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
    - 1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
    - 2) Under footings: Restore to the proper elevation using one of the following:
      - a) Aggregate base course.
  - e. Excavation width:
    - 1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.



- 2) Do not undercut slopes.
- f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
- 3. Necessary over excavation:
  - a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
  - b. Backfill voids with material acceptable to the Engineer:
    - 1) With acceptance of the Engineer, backfill with one of the following:
      - a) Aggregate base course.
      - b) Controlled low-strength material.
- F. Materials for backfills, embankments, fills, and roadway fills:
  - 1. General:
    - a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
  - 2. Backfills:
    - a. Backfill adjacent to structures, slabs, or walls: Native material Granular fill material or imported material meeting the requirements of native material granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
    - c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  - 3. Fills:
    - a. Native material Granular fill material or imported material meeting the requirements of native material Granular fill material, unless otherwise specified or indicated on the Drawings.
    - b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
  - 4. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
    - a. Aggregate base course material.
- G. Placement:
  - 1. General:
    - a. Lines and grades:
      - 1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
      - 2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
  - 2. Backfills:
    - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    - c. Defective compacted backfills: Remove and recompact.



3. Fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted fills: Remove and recompact.
4. Roadway fills:
  - a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
  - b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
  - c. Defective compacted roadway fills: Remove and recompact.

### 3.04 FIELD QUALITY CONTROL

#### A. Tests:

1. Confirmation tests:
  - a. Contractor's responsibilities:
    - 1) Accomplish specified compaction for backfills, fills, and other earthwork.
    - 2) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
    - 3) Cost of confirmation tests: Paid for by the Contractor.
    - 4) Qualifications of Contractor's testing laboratory: Perform confirmation testing by soils testing laboratory acceptable to the Engineer.
    - 5) Copies of confirmation test reports: Submit promptly to the Engineer.
  - b. Frequency of confirmation testing:
    - 1) Perform testing not less than the following:
      - a) In-place density:
        - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
        - (2) Cuts: 20 cubic yards.
        - (3) Fills: 20 cubic yards.
        - (4) Roadway fills: 20 cubic yards.
      - b) Maximum dry density versus moisture:
        - (1) Backfill: 2,500 square feet of compacted area or for every 100 linear feet of backfill.
        - (2) Cuts: 20 cubic yards.
        - (3) Fills: 20 cubic yards.
        - (4) Roadway fills: 20 cubic yards.
2. Compliance tests:
  - a. Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.
  - b. Remove overburden above level at which the Engineer wishes to test. Backfill and recompact excavation after testing is completed.
  - c. If compaction fails to meet specified requirements, perform remedial work by one of the following methods:
    - 1) Remove and replace materials at proper density.
    - 2) Bring density up to specified level by other means acceptable to the Engineer.



- d. Retesting:
  - 1) Contractor bears the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
  - 2) Contractor's confirmation tests during performance of remedial work: Double the normal rate specified.

B. Tolerances:

- 1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
  - a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
  - b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.
- 2. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
  - a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
  - b. Intent of proceeding is to avoid sandy or gravelly areas.
- 3. Finish grading of surfaces:
  - a. Reasonably smooth, compacted, and free from irregular surface changes.
  - b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
  - c. Uniformly grade areas that are not under concrete.
  - d. Finish ditches and gutters so that they drain readily.

### **3.05 ADJUSTING**

- A. Finish grades of excavations, backfills, and fills:
  - 1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

### **3.06 PROTECTION**

- A. Finish grades of backfills, cuts, excavations, and fills:
  - 1. Protect newly graded areas from erosion and deterioration by action of the elements.
- B. Ditches and gutters:
  - 1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION



## SECTION 02312

### CONTROLLED LOW STRENGTH MATERIAL (CLSM)

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Controlled low strength material (CLSM), also known as “flowable fill.”

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
  - 1. 229R - Report on Controlled Low-Strength Materials.
  - 2. 301 - Specifications for Structural Concrete.
- B. ASTM International (ASTM):
  - 1. C94 - Standard Specification for Ready Mix Concrete.
  - 2. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
  - 3. C150 - Standard Specification for Portland Cement.
  - 4. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
  - 5. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
  - 6. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  - 7. D4832 - Standard Test Method of Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
  - 8. D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material.
  - 9. D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material.

##### 1.03 SYSTEM DESCRIPTION

- A. Mixture of portland cement, water, pozzolan, fine aggregate and admixtures, proportioned in accordance with the recommendations of ACI 229 to produce a homogeneous mixture that is flowable, that will readily work into corners and angles; that will not segregate in the plastic state; and that is self-compacting at the time of placement without the use of mechanical vibration.
- B. Performance requirements:
  - 1. Air content, total calculated in accordance with ASTM D6023: Not less than 8.0 percent, nor greater than 12.0 percent.
  - 2. Compressive strength, measured in accordance with ASTM D4832 at 28 days: Not less than 50 pounds per square inch, nor greater than 150 pounds per square inch.
  - 3. Wet density: Not greater than 132 pounds per cubic foot.
  - 4. Slump, measured in accordance with ASTM C143 at the point of placement: Greater than 9 inches and that allows CLSM to flow freely and to be self-compacting during placement.



## **.04 SUBMITTALS**

- A. Product data: Submit data completely describing materials in the mix and demonstrating compliance with the requirements of this Section.
  - 1. Cement: Mill tests. Indicate alkali content representative of each shipment.
  - 2. Fly ash: Identify source and type of fly ash.
  - 3. Water: Identify source and quality if not from a municipal treatment source.
  - 4. Admixtures: Manufacturer's product data indicating suitability for use in CLSM mixes and recommended dosage rates.
  - 5. Aggregate:
    - a. Submit source, type, and sieve analyses.
    - b. Resubmit at any time there is a significant change in grading of materials.
- B. Mix design:
  - 1. Submit full details, including mix design calculations for mix proposed for use.
  - 2. Trial batch test data:
    - a. Submit data for each test cylinder.
    - b. Submit data that identifies mix and slump for each test cylinder.

## **1.05 DELIVERY, STORAGE AND HANDLING**

- A. Store or stockpile cement, fly ash, and aggregate in accordance with ACI 301.
- B. Store admixtures in accordance with the manufacturer's recommendations.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Cement:
  - 1. Portland cement in accordance with ASTM C150 Type I or Type II.
  - 2. Having total alkali content not more than 0.60 percent.
- B. Fly ash: Class C or Class F fly ash in accordance with ASTM C618.
- C. Water:
  - 1. Potable water: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
- D. Admixtures: Products of a single manufacturer, specifically manufactured or recommended by that manufacturer for use in CLSM.
  - 1. Air entraining admixture: In accordance with ASTM C260.

### **2.02 MIXES**

- A. See System Description for performance requirements of the plastic and hardened mix.



## 2.03 SOURCE QUALITY CONTROL

- A. Trial batch:
  - 1. After mix design has been accepted by Engineer, have trial batch of the accepted mix design prepared by testing laboratory acceptable to Engineer.
  - 2. Prepare trial batches using the specific cement, fly ash, admixtures, aggregates, and water proposed for the Work.
  - 3. Prepare trial batch with quantity sufficient to determine slump, workability, and consistency; and to provide test cylinders as indicated in the this Section.
- B. Trial batch testing:
  - 1. Determine slump in accordance with ASTM C143, with the following modifications:
    - a. Do not rod the concrete material.
    - b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
  - 2. Prepare and test trial batch specimens in accordance with ASTM D4832, with the following modifications:
    - a. Provide cylindrical test specimens, each 6-inches in diameter by 12-inch high.
    - b. Provide a minimum of 8 cylinders for testing of each trial batch.
    - c. Fill the molds to overflowing and tap sides lightly to settle the mix.
    - d. Do not rod the mix for consolidation in the cylinder.
    - e. Strike off the excess material.
  - 3. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
  - 4. Do not remove the test cylinder from mold until that cylinder is to be capped and tested.
    - a. Perform the capping carefully to prevent premature fractures.
    - b. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
  - 5. Provide compressive strength tests:
    - a. Test 4 test cylinders at 7 days after casting, and another 4 cylinders at 28 days after casting.
    - b. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
- C. If the trial batch tests do not meet the Specifications for strength or density, revise and re-submit the mix design, prepare additional trial batch(es), and complete additional trial batch tests. Repeat until an acceptable trial batch is that conforms to the Specifications is produced.
  - 1. All the trial batches and acceptability of materials shall be paid by the Contractor.
  - 2. After acceptance, do not change the mix design without submitting a new mix design, trial batches, and test information.





## **ART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Do not place CLSM until preparation and condition of surfaces receiving the fill have been observed and accepted by the Engineer.
- B. Remove debris foreign matter, and standing or running water from excavations and areas receiving CLSM before placement.

### **3.02 INSTALLATION**

- A. Pipes and trenches.
  - 1. Install cellular concrete as indicated on the Drawings and specified.
  - 2. Where CLSM is placed around and over pipes, secure pipes in place, or place CLSM in lifts to prevent pipe flotation.
  - 3. Where CLSM is placed in long, open trenches, confine material using bulkheads of sandbags, earth dams, or stiffer concrete at open ends of placement.
  - 4. Place CLSM at specified access points in the abandoned in-place pipe.
- B. Soil preparation:
  - 1. Prior to placement of CLSM, prepare underlying soils as follows:
    - a. Scarify surface to a depth of 8 inches.
    - b. Adjust moisture content to or slightly above the optimum in accordance with ASTM D1557.
    - c. Re-compact scarified surface to a minimum of 95 percent relative density in accordance with ASTM D1557.

### **3.03 MEASURING, BATCHING, MIXING AND TRANSPORTING**

- A. Measure, batch, mix and transport CLSM in accordance with the requirements of ASTM C94 and this Section.
- B. Mix until there is uniform distribution of materials.
- C. Discharge mixer completely prior to recharging.
- D. After trial batch testing and mix acceptance, maintain slump during construction within plus or minus 1 inch of the design slump.

### **3.04 PLACING**

- A. Place controlled low strength material by method that preserves the quality of the material in terms of compressive strength and density.
- B. Maintain fluid properties of the mix during placement.
  - 1. At point of placement, provide material that flows easily around, beneath, or through walls, pipes, conduits, or other structures.
  - 2. Do not place CLSM that has partially hardened or that has been contaminated by foreign materials.
  - 3. Handle and place CLSM using methods that minimize segregation of the mix.





4. Deposit mix as near its final position as possible to avoid segregation due to rehandling or flowing.
5. Contain and confine mix while it is fluid. Design containment structures and bracing at walls and forms to withstand lateral pressures of wet mix.

C. Lifts:

1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings.
2. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent additional lateral load against the forms or structure due to the weight of the next lift of CLSM.

D. Water conditions:

1. Do not place CLSM in standing or flowing water.
2. Do not permit water to flow over the surface of freshly placed or un-hardened CLSM.
3. Do not submerge CLSM in water within 24 hours after placement.

E. Manage CLSM bleed water.

1. Grade top surface of CLSM to drain away from the fill.
2. Provide side containment that permits bleed water to drain to a contained management area away from the fill.

### **3.05 CURING AND PROTECTION**

A. Curing:

1. Prior to and during curing, install barriers to prevent equipment or personnel from falling into or becoming entrapped in CLSM.

B. Protect CLSM from:

1. Damage from the elements.
2. Damage of any nature during surrounding construction operations.
3. Freezing: Do not use salt, manure, or other chemicals to provide cold.

### **3.06 FIELD QUALITY CONTROL**

- A. Provide quality control over the Work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan and as specified in this Section.

B. General:

1. Engineer inspection and acceptance required prior to placement.
2. Make provisions for and furnish all material for the test specimens, and provide manual assistance in preparing said specimens.

### **3.07 FIELD QUALITY ASSURANCE**

- A. Provide quality control over the work of this Section as specified in Section 01450 - Quality Control and 01460 - Contractor Quality Control Plan.

B. Field inspections:

1. Engineer shall provide on-site inspection for the Work of this Section.



2. Advise Engineer of readiness to proceed at least 24 hours prior to each placement of CLSM.
  3. Required inspections:
    - a. Engineer will observe the prepared areas. Do not place CLSM until Engineer has observed and accepted preparations.
  4. Record of inspections.
- C. Field sampling and testing:
1. During construction, Contractor shall provide sampling and testing to determine whether the CLSM, as produced and placed, complies with the requirements specified.
  2. Required tests:
    - a. Air content: Prepare sample and test in accordance with ASTM D6023
    - b. Compressive strength: Prepare and test cylinder specimens in accordance with ASTM D4832.
      - 1) Prepare 6-inch diameter by 12-inch high specimens for testing.
        - a) Provide one set of specimens for each 150 cubic yards of CLSM placed, but not less than 1 set for each half day's placement.
        - b) Prepare and test not less than 3 cylinders for each set.
        - c) Place CLSM in the molds in accordance with ASTM D4832. Do not rod or otherwise consolidate the material in the mold.
        - d) In accordance with ASTM D4832 recommendations for displacing bleed water at the top of the molds and refilling the molds before covering with a lid. Do not use air-tight lids.
      - 2) Place the cylinders in a safe location away from construction activities.
        - a) Protect cylinders from bumping and impact.
        - b) Maintain temperature surrounding cylinders between 60 and 80 degrees Fahrenheit until delivery to the laboratory for testing.
        - c) After the first day, surround molds with a high humidity environment by covering with wet burlap, or equivalent highly absorptive material. Maintain saturation of the cover. Do not sprinkle water directly on the cylinders.
      - 3) After 4 days, place the cylinders in a protective container for transport to the laboratory for testing.
        - a) Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
        - b) Transport container may be a box with a Styrofoam or similar lining that will limit jarring and bumping of the cylinders.
      - 4) Upon receipt at the testing laboratory, place test cylinders in a moist curing room until dates for testing.
      - 5) Do not remove test cylinders from molds until the day that cylinders is to be capped and tested.
      - 6) Cap and test for compressive strength in accordance with ASTM D4832.
        - a) Do not perform initial compression test until the cylinders reach an age of at least 4 days.
        - b) Test 1 cylinder at 7 days and 2 at 28 days.
      - 7) Compressive strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength specified.



### 3.08 NON-CONFORMING WORK

- A. When testing or observation indicates CLSM with properties outside the specified and accepted range, Engineer will issue instructions regarding disposition of nonconforming materials.
- B. Engineer may:
  - 1. Reject CLSM represented by those test specimens and require its removal and replacement.
  - 2. Require modification of the mix design to provide CLSM with the properties specified.
- C. Make such modifications at no additional expense to the Owner and with no adjustment to the schedule.

END OF SECTION





## **SECTION 02318**

### **TRENCHING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Trench excavation and trench backfill.

##### **1.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
  - 2. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>).
  - 3. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

##### **1.03 SUBMITTALS**

- A. As specified in Section 01330 - Submittal Procedures.
- B. Product data on soils and aggregates.
  - 1. Material source.
  - 2. Gradation.
  - 3. Test data to demonstrate compliance with this Section.
- C. Samples:
  - 1. Provide 50-pound sample of materials when requested by the Engineer.
- D. Confirmation testing:
  - 1. Certification of Contractor's testing laboratory.
  - 2. Record copy report for tests performed by Contractor's testing laboratory.

##### **1.04 DEFINITIONS**

- A. Backfill: Material placed in trench above the pipe embedment zone.
- B. Bedding: Material placed under, around, and over pipes or ducts in trenches.
- C. Center bedding: Material placed at the bottom of the trench directly under the center of the pipe to provide a malleable resting surface.
- D. Fine grading: Material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.



- E. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.
- F. Haunch zone: Material placed below and beside the pipe up to the pipe springline.
- G. Lift: A layer of soil or aggregate material, measured before compaction.
- A. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
- B. Maximum density, field compaction: Soil density and water content when tested in accordance with ASTM D1556.
- C. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.
- D. Pipe embedment zone: Includes bedding, fine grading, center bedding, and haunch zone.
- E. Pipe foundation: Material placed at the bottom of trench to provide support.
- F. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.
- G. Rigid pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. As specified in Section 02050 - Soils and Aggregates for Earthwork.
- B. Class C concrete: As specified in Section 03300 - Cast-in-Place Concrete.
- C. Controlled low-strength material: As specified in Section 02312 - Controlled Low Strength Material (CLSM).

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.



### 3.02 DEWATERING

- A. As specified in Section 02240 - Dewatering.

### 3.03 TRENCH EXCAVATION

- A. Excavate bottom of trench to depth indicated on the Drawings.
- B. Areas of new fill or embankment:
1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
  2. Excavate through fill for pipe trench.
- C. Trench widths as specified in the following table:

Buried Pipe Or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

- D. Potable water pipe and appurtenances:
1. Lay in trenches separate from those used for sewers.
  2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.

### 3.04 TRENCH BACKFILL - GENERAL

- A. Trench area terminology and locations as indicated on the Drawings.
- B. Place material, except CLSM and concrete, in maximum 6 inch lifts, measured before compaction.
- C. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

### 3.05 PIPE FOUNDATION

- A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.
1. Prepare pipe foundation, with any unauthorized excess excavation below elevation indicated on the Drawings, at no additional cost to Owner.
- B. If bottom of trench excavation consists of soil:
1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.



2. Materials and placement:
  - a. Recompact scarified material to 95 percent of maximum density.
- C. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
  1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
  2. Materials:
    - a. CLSM.
    - b. Class C concrete.
- D. If bottom of trench excavation consists of unacceptable material:
  1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
  2. Material and placement:
    - a. Aggregate base course material compacted to 95 percent of maximum density.
      - 1) Maximum particle size for backfill material limited as specified in the following table:

Buried Pipe	Maximum Particle Size
Nominal Pipe Diameter: 6 inch to 8 inch	3/4 inch
Nominal Pipe Diameter: 10 inch to 16 inch	1 inch
Nominal Pipe Diameter: Greater than 18 inch	1 1/2 inches

### 3.06 PIPE EMBEDMENT ZONE

- A. General:
  1. Pipe displacement:
    - a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
    - b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
  2. Depressions for joints or couplings:
    - a. Excavate holes in graded trench bottom.
    - b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
- B. Rigid pipe:
  1. Fine grading:
    - a. Compacted depth below bottom of pipe: 6 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
  2. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.





- C. Flexible pipe:
  - 1. Center bedding:
    - a. Compacted depth below bottom of pipe: 12 inch minimum.
    - b. Compacted width below bottom of pipe: 1/3 of pipe outer diameter.
    - c. Materials and placement:
      - 1) Sand bags.
      - 2) Uncompacted sand at uniform density, minimize compaction.
  - 2. Haunch zone:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.
  - 3. Bedding:
    - a. Compacted depth above top of pipe: 12 inch minimum.
    - b. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent maximum dry density.
      - 2) CLSM.

### **3.07 BACKFILL**

- A. Trenches:
  - 1. Materials and placement:
    - a. Native soil compacted to 95 percent maximum dry density.
    - b. Imported fill compacted to 95 percent maximum dry density.
    - c. Aggregate base course compacted to 95 percent maximum dry density.
    - d. CLSM.
- B. Trenches in rock:
  - 1. Backfill to top of rock.
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.
  - 2. Backfill from top of rock to grade, if applicable:
    - a. Materials and placement:
      - 1) Aggregate base course compacted to 95 percent of maximum density.
- C. Trenches below or within 10 feet of the outside perimeter of structures:
  - 1. Backfill within aggregate base course below structure.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- D. Trenches in roadways and paved areas:
  - 1. Backfill trench to underside of pavement.
  - 2. Materials and placement:
    - a. Aggregate base course compacted to 95 percent of maximum density.
    - b. CLSM.
- E. Trenches in areas outside the improved section of roadways or in open country:
  - 1. Backfill to finished grade.



2. Materials and placement:
  - a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.
- F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
  1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
    - a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
    - b. Materials and placement:
      - 1) CLSM, unless otherwise indicated on the Drawings.
  2. Backfill remainder of trench:
    - a. Materials and placement:
      - 1) CLSM.
      - 2) Class C concrete.

### **3.08 EXCESS MATERIAL**

- A. Remove excess excavated material from the Project site as specified in Section 02300 - Earthwork.

### **3.09 FIELD QUALITY CONTROL**

- A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.
- B. Confirmation tests: As specified in Section 02300 - Earthwork.
  1. Minimum frequency of confirmation testing:
    - a. At each test location include tests for each type or class of backfill from bedding to finished grade.
    - b. For trenches: 1 location every 200 linear feet.
    - c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
    - d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
    - e. Crossing paved roads: 1 location at each crossing.
    - f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.
- C. Compliance tests:
  1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
  2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
    - a. Remove and replace backfill at the proper density.
    - b. Other means acceptable to the Engineer.
  3. Retesting:
    - a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.



- b. Contractor's confirmation tests during performance of remedial work:
  - 1) Performance: Perform tests in manner acceptable to the Engineer.
  - 2) Frequency: Double amount specified for initial confirmation tests.

D. Piping system testing:

- 1. As specified in Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 02600

### CONCRETE MANHOLES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Manhole frames and covers.
  - 2. Manhole grade rings.
  - 3. Manholes cones and risers.
  - 4. Manhole bases.

##### 1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO).
  - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
  - 1. A48 - Standard Specification for Gray Iron Castings.
  - 2. C33 - Standard Specification for Concrete Aggregates.
  - 3. C150 - Standard Specification for Portland Cement.
  - 4. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
  - 5. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
  - 6. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
  - 7. C923 - Standard Guide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.
  - 8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
- C. International Organization of Standardization (ISO):
  - 1. 9001 - Quality Management Standard.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings:
  - 1. Manufacturer's catalog data and details of following items for approval:
    - a. Frame and covers.
    - b. Grade rings.
    - c. Manhole cones and risers.
    - d. Manhole bases, if precast.
  - 2. Manhole construction details, jointing methods, connection details, materials, and dimensions.
  - 3. Repair procedures and details.



- C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.
- D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.
- E. Sealed drawings and design calculations by a registered Professional Engineer licensed in the State where the project is located.
- F. Certificates
  - 1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
  - 2. Manufacturer's Certificate of Source Testing.

#### **1.04 PRODUCT REQUIREMENTS**

- A. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
  - 1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
  - 2. Dragging or dropping the manhole components shall not be allowed.
- B. Source testing.
  - 1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
    - a. In lieu of this experience, witness of tests by up to 3 full-time Owner representatives.
  - 2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
  - 3. Complete required testing in accordance with ASTM C478.
  - 4. Provide the Manufacturer's Certificate of Source Testing.

#### **1.05 DESIGN CRITERIA:**

- A. Manholes shall not include steps.
- B. Manhole lids: Locking (watertight) type.
- C. Manhole bases:
  - 1. Constructed in accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
- D. Manhole riser:
  - 1. In accordance with Little Rock Water Reclamation Authority Standard Details and ASTM C478.
  - 2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.
- E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.



- F. Manhole systems:
  - 1. Provided by a single manufacturer.
- G. Frames and covers:
  - 1. Provided by a single manufacturer unless approved by the Engineer.

## **1.06 WARRANTY**

- A. As specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Manhole grade rings, cones, and risers: One of the following or equal.
  - 1. Peterson Concrete.
- B. Manhole frames and covers: Manufacturers: One of the following or equal.
  - 1. East Jordan Iron Works – Model V2418.
  - 2. Neenah Foundry Company.

### **2.02 BASIS OF DESIGN**

- A. Design in accordance with local jurisdiction requirements and Little Rock Water Reclamation Authority Standard Details, including but not limited to the following:
  - 1. Manhole frames and covers.
  - 2. Manhole diameter tolerance.
  - 3. Manhole length.
  - 4. Manhole cover bolting.
  - 5. Manhole backfill.
- B. Structural design calculations:
  - 1. Load rating of manhole:
    - a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
  - 2. Resist buoyancy:
    - a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
    - b. Depths will be as indicated on the Drawings.
    - c. Refer to the geotechnical report for soil condition including fully saturated soil conditions.
- C. Manholes, grade rings, risers, and bases:
  - 1. Manhole:
    - a. Nominal sizes as indicated on the Drawings.
  - 2. Grade rings:
    - a. At least 1 but not more than 2 grade rings shall be used.
    - b. Maximum total distance from top of cone section to final grade: In accordance with Little Rock Water Reclamation Authority Standard Details.



3. Cone and riser sections:
  - a. As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
  - b. Cone sections shall be concentric.
4. Manhole bases:

As specified in this Section and as indicated in the Little Rock Water Reclamation Authority Standard Details.
- D. Threaded lifting inserts:
  1. Design inserts to be fully threaded:
    - a. Do not fully penetrate through entire manhole wall.
  2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
  3. Design with minimum safety factor of 4.0.
  4. Do not use reinforcing steel bars.

## 2.03 MATERIALS

- A. Cast iron manhole frames and covers.
  1. In accordance with ASTM A48 and Little Rock Water Reclamation Authority Standard Details.
  2. Covers: Bolted (Watertight) as specified.
  3. Concrete collars: As indicated on the Drawings.
- B. Manhole bases, risers, and grade rings:
  1. Cement: Type II portland cement in accordance with ASTM C150.
  2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
  3. Sections: Steel reinforced.
  4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
  5. Top and bottom of sections: Parallel.
  6. In accordance with Little Rock Water Reclamation Authority Standard Details.
- C. Joint sealant:
  1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
  2. Manufacturers: One of the following or equal.
    - a. Tylox Superseal.
    - b. Kent Seal - Hamilton Kent Corp.
- D. Exterior joint wrap:
  1. Butyl based seal that is self-priming, self-sealing, and permanently flexible designed to create a high-performance seal in precast structures.
  2. Sealant shall provide a flexible watertight seal around perimeter of joint.
  3. Seal shall be highly resistant to temperature extremes and acid or caustic environments.
  4. Width = 6" minimum.
  5. Manufacturers: One of the following or equal.
    - a. Sealing Systems Inc. - Infi-Shield Gator Wrap.
    - b. Trelleborg – Bidco External Joint Wrap.





## **2.04 COMPONENTS**

- A. Pipe stubs:
  - 1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
  - 2. Plugging stubs:
    - a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
    - b. Unless otherwise indicated on the Drawings, comply with following:
      - 1) Stubs up to and including 21 inches: Vitrified clay stoppers.
      - 2) Stubs greater than 21 inches: Brick plugs.
- B. Resilient pipe connectors:
  - 1. Unless otherwise indicated on the Drawings or specified, provide a flexible watertight compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
  - 2. Resilient pipe connectors:
    - a. Manufacturers: The following or equal.
      - 1) A-LOK Premium.
      - 2) NPC Kor-N-Seal.
- C. Threaded lifting inserts.
- D. Drop manholes:
  - 1. Construct drop manholes at locations and in accordance with details indicated on the Drawings in accordance with Little Rock Water Reclamation Authority Standard Details.
  - 2. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
  - 3. Furnish and set fittings as indicated on the Drawings.

## **2.05 IDENTIFICATION MARKINGS**

- A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
  - 1. Date of manufacture of the item.
  - 2. Name or trademark of the manufacturer.
  - 3. Internal diameter in inches.
  - 4. Number of the manhole as indicated on the Drawings.

## **2.06 QUALITY CONTROL**

- A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.
- B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the Owner or Owner's representative.
- C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
  - 1. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.



2. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe.
  - a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
  - b. Devices are subject to inspection by Engineer.
- D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.
- E. Remove rejected manholes immediately.

## **PART 3 EXECUTION**

### **3.01 MANHOLE INSTALLATION**

- A. Excavate and backfill as specified in Section 02318 - Trenching and as indicated on the Drawings.
- B. Maintain identification markings on installed pieces throughout installation.
- C. Do not use sections with chips or cracks in the joint.
- D. Engineer may inspect manhole sections, prior to installation.
- E. Repair of manhole sections damaged during installation in accordance with manufacturer's repair procedures; with the concurrence of the Engineer.
- F. Install joint sealant material in accordance with manufacturer's instructions:
  1. Completed manhole: Rigid and watertight.
- G. Fill threaded lifting inserts with grout.
- H. Lay grade rings on joint sealant with sides plumb and tops level.
- I. Set frame and covers as specified and as indicated on the Drawings.
- J. Damproofing is not required.

### **3.02 CLEANING**

- A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.
- B. After completing each manhole, remove construction material debris from inside the manhole.

### **3.03 FUNCTIONAL TESTING**

- A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.



- B. Vacuum testing in accordance with ASTM C1244.
1. Install the vacuum test head on top of the manhole.
    - a. Install and brace sealing devices on influent and effluent pipes.
  2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
  3. Compare test results with the minimum time requirements stated in the table below.
    - a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

<b><u>Minimum Elapsed Time, Minutes: Seconds</u></b>				
<b>Manhole Depth, ft.</b>	<b>Manhole Diameter, inches</b>			
	36	48	60	72
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:46	0:57
16	0:28	0:40	0:52	1:07
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:05	1:21
22	0:38	0:55	1:12	1:29
24	0:42	0:59	1:18	1:37
26	0:46	1:04	1:25	1:45
28	0:49	1:09	1:31	1:53
30	0:53	1:14	1:38	2:01

END OF SECTION





## SECTION 02621

### STABILIZATION FABRIC

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Woven stabilization fabric used for subgrade enhancement.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
  - 2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
  - 3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
  - 4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
  - 5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
  - 6. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
  - 7. D4595 - Standard Test Method for Tensile Properties of Geotextiles by the wide strip method.

##### 1.03 DEFINITIONS

- A. Stabilization fabric: Woven geotextile fabric manufactured from polypropylene yarns.

##### 1.04 SUBMITTALS

- A. Product data.
- B. Samples.
- C. Quality control submittals:
  - 1. Certificates of Compliance.
  - 2. Manufacturer's Installation Instructions.

##### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection:
  - 1. Furnish stabilization fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.



## 06 PROJECT CONDITIONS

- A. Field measurements:
1. Take field measurements to determine the exact lengths and dimensions of the surfaces to receive the fabric.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

- A. One of the following or equal:
1. Propex, Geotex 2x2HF.
  2. Ten Cate Geosynthetics, Mirafi HP270.

### 2.02 MATERIAL REQUIREMENTS

- A. Physical properties: Meet the following minimum requirements:

Property <sup>(1)</sup>	Test Method	Unit	Requirements <sup>(1)</sup>
Grab Tensile Strength	ASTM D4595	lbs	2640
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	80
Apparent Opening Size (AOS)	ASTM D4751	US sieve	30
Permittivity	ASTM D4491	sec <sup>-1</sup>	0.06
Flow Rate	ASTM D4491	gpm/ft <sup>2</sup>	40
(1) Minimum average roll values.			

## PART 3 EXECUTION

### 3.01 EXAMINATION

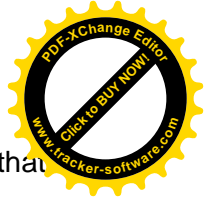
- A. Verification of conditions: Verify that conditions are satisfactory for the installation of stabilization fabric.

### 3.02 PREPARATION

- A. Surface preparation: During grading operations, take care not to disturb the subgrade. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.
- B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

### 3.03 INSTALLATION

- A. Follow manufacturer's installation instructions and as complimented in this Section.
- B. Place the stabilization fabric smoothly without folds or wrinkles.



- C. Use special care when placing the stabilization fabric in contact with the soil so that no void spaces occur between the stabilization fabric and the prepared surface.
- D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than recommended by manufacturer.
- E. Do not drag stabilization fabric across subgrade.
- F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.
- G. Use lightweight dozers, if necessary. Do not allow equipment directly on stabilization fabric.

#### **3.04 FIELD QUALITY CONTROL**

- A. Inspection: Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. Repair all holes or rips by placing a new layer of fabric extending beyond the defect in all directions, a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION







## SECTION 02772

### CONCRETE CURBS, GUTTERS, AND SIDEWALKS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

##### 1.02 SYSTEM DESCRIPTION

- A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

##### 1.03 SUBMITTALS

- A. Product data: Submit data completely describing products.
- B. Samples: Submit samples when requested.

#### PART 2 PRODUCTS

##### 2.01 MATERIALS

- A. Concrete: Class A, as specified in Section 03300 - Cast-In-Place Concrete.
- B. Curb finishing mortar: 1 part portland cement to 2 parts sand.
- C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.
- D. Joint materials:
  - 1. Expansion: As specified in Section 03150 - Concrete Accessories.

#### PART 3 EXECUTION

##### 3.01 EXAMINATION

- A. Verification of Conditions:
  - 1. Verify field conditions, including subgrade condition and interferences, before beginning construction.



## 3.02 PREPARATION

- A. Surface preparation:
  - 1. Subgrade:
    - a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 02050 - Soils and Aggregates for Earthwork.
    - b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
  - 2. Forms and subgrade: Water immediately in advance of placing concrete.

## 3.03 INSTALLATION

- A. Special techniques:
  - 1. Contractor's option:
    - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the Engineer.
    - b. When use of machines designed specifically for work of this Section are accepted by the Engineer, results must be equal to or better than those produced by use of forms.
    - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
    - d. Discontinue use of machines when results are not satisfactory to the Engineer.
- B. Forms:
  - 1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
  - 2. Thoroughly clean prior to each use and coat with form releasing material.
- C. Expansion and weakened-plane joints:
  - 1. Expansion joints:
    - a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
    - b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
    - c. Fill joints with expansion joint filler material.
  - 2. Weakened-plane joints:
    - a. Construct as indicated on the Drawings.
    - b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.
- D. Concrete:
  - 1. Placing:
    - a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
  - 2. Compacting:
    - a. Compact by mechanical vibrators accepted by the Engineer.
    - b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.



3. Form removal:
  - a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
  - b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
4. Finishing and curing: Comply with requirements as specified in Section 03366 - Tooled Concrete Finishing except as modified here:
  - a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
  - b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
  - c. Edge concrete at expansion joints to 1/4 inch radius.
  - d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.
  - e. Sidewalks and ramps: Broom finish

E. Backfilling:

1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

### 3.04 FIELD QUALITY CONTROL

A. Tests:

1. Curbs and gutters:
  - a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
  - b. Correct deviations in excess of 1/4 inch.
2. Gutters:
  - a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
  - b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
  - c. Required results:
    - 1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
    - 2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

### 3.05 ADJUSTING

- A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.



- B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION



## SECTION 02939

### SEEDING

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## **ART 1    GENERAL**

### **1.01    SUMMARY**

- A.    Section includes seeding.

### **1.02    REFERENCES**

- A.    Association of Official Seed Analysts (AOSA).
- B.    United States Department of Agriculture (USDA).
- C.    United States Environment Protection Agency (EPA).

### **1.03    DEFINITIONS**

- A.    Duff layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B.    Finish grade: Elevation of finished surface of planting soil.
- C.    Manufactured topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D.    Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- E.    Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F.    Planting soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- G.    Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- H.    Surface soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.
- I.    Weeds:
  - 1.    Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Russian Thistle, Leafy Spurge, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Weed, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.



## 1.04 SUBMITTALS

- A. Product data: For each type of product indicated:
  - 1. Pesticides and herbicides: Include product label and manufacturer's application instructions specific to this Project.
  - 2. Fertilizer and organic matter: Include product label and manufacturer's application instructions specific to this Project.
  - 3. Soil amendment: Analysis.
- B. Certification of grass seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
  - 1. Certification and inspection as required by governmental authorities of each seed mixture. Include identification of source and name and telephone number of supplier.
- C. Qualification data: For qualified landscape Installer.
- D. Samples: Imported topsoil, organic matter, erosion control blanket and mulch.
- E. Product certificates: For soil amendments and fertilizers, from manufacturer.
- F. Maintenance instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

## 1.05 QUALITY ASSURANCE

- A. Installer qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
  - 1. Professional membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
  - 2. Experience: 5 years' successful experience in the installation of seeded areas similar in size to this project.
  - 3. Installer's field supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  - 4. Personnel certifications: Installer's field supervisor shall have certification in all of the following categories from the Professional Landcare Network:
    - a. Certified Landscape Technician - Exterior, with installation and irrigation specialty area(s).
  - 5. Maintenance proximity: Not more than 2 hours' normal travel time from Installer's place of business to Project site.
  - 6. Pesticide applicator: State licensed, commercial.
- B. Soil-testing laboratory qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter;



gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil. Refer to plan notes for number and location of soil analysis tests.

1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Engineer.
  - a. A minimum of 3 representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.
  - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated.
    - 1) State recommendations in weight per 1,000 square feet or volume per cubic yard for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
  - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Pre-installation conference: Conduct conference at project site.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Seed and other packaged materials:
  1. Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
  2. Protect seed during delivery and storage.
  3. Seed that has become wet or otherwise damaged will not be acceptable.
- B. Deliver packaged materials in waterproof bags showing weight, chemical analysis and name or trademark of manufacturer.
  1. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, percentage of purity (PLS), percentage of germination and location of packaging.
- C. Local sourcing of seed not in sealed containers is permitted for smaller projects.
- D. Label seed bags per variety.
- E. Store materials in protected and covered storage until application or use.
- F. Bulk materials:
  1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.





- G. Truck receipts: For verification of all soil amendments and imported topsoil.
- H. Hydroseeding:
  - 1. Ensure that seed packages are packed to provide adequate protection against injury during transit.
  - 2. Deliver undamaged sealed seed bags with legible labels showing weight, analysis, vendor's name and address, and point of origin.
    - a. Label seed bags per variety.
  - 3. Deliver dry commercial process or packaging, such as fertilizer, in undisturbed original unopened containers with legible labels showing the manufacturer's guaranteed analysis or description.
  - 4. Inspect materials and packages upon delivery.
    - a. Discard damaged packages or containers immediately.
  - 5. Store materials in protected and covered storage until application or use.

## **1.07 WARRANTY**

- A. Warranty:
  - 1. Guarantee all seeding to be alive and healthy for 1 years following date of final completion by the Engineer.
  - 2. Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
  - 3. All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
  - 4. The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
  - 5. Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
  - 6. Maximum single bare spot size of non-irrigated seed is 1 square foot.
  - 7. All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
- B. Replace seeding when it is no longer in a satisfactory condition or do not meet the preceding standard as determined by the Engineer or the duration of the Guarantee/Warranty Period.
  - 1. Make replacements as soon as possible within the recommended seeding schedule.
- C. Replacements:
  - 1. Seed of same mix, quality and species as originally specified, as soon as possible within the recommended seeding schedule, with a new 1-year warranty commencing on date of replacement.
  - 2. Repairs and replacements shall be made at no expense to the Owner.

## **PART 2 PRODUCTS**

### **2.01 STAKES**

- A. Softwood lumber, chisel pointed.

### **2.02 SOIL AMENDMENTS AND FERTILIZERS**

- A. Apply soil amendments and fertilizer as indicated on the Drawings.



- B. Submit soil amendment and fertilizer recommendations, along with supporting soil test analysis, for Engineer approval prior to application on the site.
- C. Fertilizer:
  - 1. Uniform in composition, free flowing and suitable for application with approved equipment, of the proportions necessary to eliminate any deficiencies of topsoil, as indicated in analysis.
  - 2. Delivered to the site fully labeled according to applicable laws.
  - 3. Packaging: Display the name, tradename, trademark and warranty of the provider.
- D. Fertilizer grade description format:
  - 1. Three sets of 2-digit numbers.
  - 2. Numbers represent the percent by weight of nutrients.
  - 3. First number is the amount of nitrogen (N).
  - 4. Second number is the amount of phosphate (P<sub>2</sub>O<sub>5</sub>).
  - 5. Third number is the amount of potash (K<sub>2</sub>O).
  - 6. Example: 10 10 10.

### **2.03 HERBICIDE AND PESTICIDE**

- A. Submit labels for Engineer approval.
- B. Pesticides:
  - 1. Registered and approved by EPA.
  - 2. Acceptable to authorities having jurisdiction.
  - 3. Type recommended by manufacturer for each specific problem.
  - 4. As required for Project conditions and application.
  - 5. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- C. Pre-emergent herbicide (Selective and Non-Selective):
  - 1. Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- D. Post-emergent herbicide (Selective and Non-Selective):
  - 1. Effective for controlling weed growth that has already germinated.

### **2.04 WATER**

- A. Use potable water for making up seed mixture.
- B. Plant effluent may be used for hydroseeding watering and maintenance with Owner approval, as specified in this Section.

### **2.05 SOILS**

- A. Topsoil:
  - 1. Fertile soil, typical for locality, capable of sustaining vigorous plant growth.
  - 2. Taken from drained site.
  - 3. Free of subsoil, stones more than 1 inch in diameter, clay clumps, or impurities, plants weeds and roots.
  - 4. Organic content:



- a. Minimum 2 percent by mass.
5. pH value:
  - a. Minimum: 5.5.
  - b. Maximum: 7.5.

## 2.06 SEED

- A. Provide seed as indicated on the Drawings.
- B. Packaging: Provide separate bags or containers for each variety of seed.
- C. Plant seed that is appropriate for planting season.
- D. Provide seed from tested lots and delivered to project site in standard containers labeled as required by U.S. Department of Agriculture regulations and applicable state regulations.
- E. Use labels that show variety of strain of seed, degree of purity (percent), rate of germination (percent), weed content (percent), and date of test.
- F. Lawn seed:
  1. Common name: Bermuda grass (*Cynodon Dactylon*).
  2. Planted from April 15 to July 15.
  3. Fancy hulled seed.
  4. Seed mixture:
    - a. Germination minimum: 88 percent.
    - b. Pure seed minimum: 94 percent.
    - c. Weed seed maximum: 0.35 percent.
- G. Grass seed:
  1. Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
  2. Species: Match existing grass type.
  3. Seed mixture:
    - a. Germination minimum: 95 percent.
    - b. Pure seed minimum: 85 percent.
    - c. Weed seed maximum: 0.5 percent.
    - d. Other than grass seed, non-viable seed, chaff, hulls, live seed of crop plants (other than those specified), harmless inert matter, and maximum: 18 percent.
  4. Proprietary seed mix: Western Native Seed near Salida, CO.
- H. Buffalo grass mix:
  - a. Common name: "Topgun" or "Texoka" seed.
  - b. Drill rate: 90 pounds of seed per acre (2 pounds 100 feet square).
  - c. Timing: April 1 - September 1.
  - d. Cannot be hydro-mulched.
    - 1) Areas susceptible to erosion: Cover drilled seeded area with hydro-mulched fiber.
- I. Wildflower seed:
  1. Wildflower seed mix from latest crop.
  2. Seed mixture:



- a. Pure live seed content minimum: 80 percent.
3. Seed testing maximum: 6 months from planting date.
  - a. Do not use seed mix after expiration date.
4. Seeding rate:
  - a. *Lupinus luteus*: 8 pounds per acre.
  - b. *Eschscholtzia Californica*: 1.9 pounds per acre.
  - c. *Gazania Splendeus*: 12 pounds per acre.
  - d. *Clarkia Amoena*: 4.5 pounds per acre.
  - e. *Lasthenia Glabrata*: 4 pounds per acre.
  - f. *Achillea Borealis*: 3 pounds per acre.
  - g. *Stipa Pulchrum*: 3 pounds per acre.
  - h. *Gilia Capitata*: 6 pounds per acre.
  - i. *Festuca Idahoeasis*: 4 pounds per acre.
- J. Erosion control seed:
  1. Erosion control seed mix from latest crop.
  2. Seed mixture:
  3. Pure live seed content minimum: 80 percent.
  4. Seed testing maximum: 6 months from planting date.
    - a. Do not use seed mix after expiration date.
  5. Seeding rate:
    - a. Blando Brome: 20 pounds per acre.
    - b. Annual Rye: 25 pounds per acre.
    - c. Rose Clover: 20 pounds per acre.
    - d. Zorro Annual Fescue: 10 pounds per acre.

## 2.07 MULCHES

- A. As indicated on the Drawings.
- B. Straw mulch:
  1. Oats, barley, wheat or rye only.
  2. Free from weeds, foreign matter detrimental to plant life, and dry.
  3. Minimum length 10 inches long: 50 percent of straw.
  4. Not acceptable:
    - a. Hay or chopped cornstalks.
    - b. Old straw mulch which breaks during crimping.
    - c. Straw in such an advanced stage of decomposition as to smother or retard the normal growth of grass.
- C. Wood cellulose fiber mulch:
  1. Wood fibers must be capable of being evenly dispersed and suspended when agitated in water.
  2. Furnish with a biodegradable green dye to allow visual metering of its application.
  3. Not acceptable:
    - a. Substance or factor which might inhibit germination or growth of grass seed, with organic tacifier.

## 2.08 HYDRO-MULCH

- A. Hydro-mulch seed:
  1. Seeding:



- a. Mixture:
  - 1) Ratio of wood cellulose fiber, seeds and fertilizer: 4:1:6 mixture.
    - a) Fiber: 20 pounds.
    - b) Seeds: 5 pounds.
      - (1) Modify mixture according to the planting season as follows:
        - (a) February through August: 20 pounds of hulled common Bermuda grass per acre.
        - (b) August through February: combination of 15 pounds of unhulled common Bermuda and 15 pounds of unhulled Gulf Coast Annual Rye seed per acre.
    - c) Fertilizer: 30 pounds.
  - 2) Coverage: 1,000 square feet.
- b. Provide a recommendation for proposed mixture based on time of year hydro-mulch is actually performed.

B. Hydro-mulching equipment:

- 1. Manufacturers: One of the following or equal:
  - a. Bowie Industries, Inc.
  - b. Reinco.
  - c. Finn Equipment Co.
- 2. Equipment requirements:
  - a. Built-in agitation system sufficient to agitate, suspend, and homogeneously mix slurry containing fiber, fertilizers, chemicals, and seed mix.
  - b. Capable of slurry distribution line large enough to prevent stoppage.
  - c. Equipped with set of hydraulic spray nozzles which provide continuous non-fluctuating discharge of minimum 225 pounds per square inch at end of spray nozzle.

## 2.09 HYDROSEEDING MATERIALS

A. Seed mix:

- 1. Manufacturers: One of the following or equal:
  - a. Grass Growers.
  - b. Conwed Corp.
  - c. Eva Cell Co.
- 2. Seed mix from the latest crop.
- 3. Minimum pure live seed content to be 80 percent, and tested within the preceding 6 months.
- 4. Do not use seed mix after expiration date:
  - a. Blando Brome: 20 pounds per acre.
  - b. Annual Rye: 25 pounds per acre.
  - c. Rose Clover: 20 pounds per acre.
  - d. Zorro Annual Fescue: 10 pounds per acre.

B. Mulch:

- 1. Wood fiber manufactured for hydroseeding: Fiber mulch:
- 2. Manufacturers: One of the following or equal:
  - a. Grass Growers.
  - b. Conwed Corp., Fibers Div.
  - c. Eva Cell Co.



- C. Water:
  - 1. Use potable water for making up seed mixture.
  - 2. Plant effluent may be used for hydroseed watering with Owner approval as specified in this Section.
- D. Granular fertilizers:
  - 1. Manufacturers: One of the following or equal:
    - a. Sierra Chemical Co.
    - b. Green Light Co., Wonder Grow Chemicals.
    - c. Kay-Fries Chemicals.
  - 2. Fertilizer grade: 16-20-0.

## **2.10 EROSION CONTROL BLANKETS**

- A. As indicated on the Drawings.
- B. Erosion control blanket:
  - 1. Manufacturer: The following or equal:
    - a. American Excelsior Company, Curlex®.
  - 2. Jute matting, open weave.
  - 3. Regular blanket, machine produced mat of curled wood excelsior of 80 percent 6 inch or longer fiber length with a consistent width of fibers evenly distributed throughout mat.
  - 4. Photo-biodegradable extruded plastic netting cover the top side of blanket.
  - 5. Secure netting to wood excelsior by extra heavy lines of plastic woven into the width of each blanket.
  - 6. Smolder resistant with no chemical additives.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
  - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
  - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 4. Uniformly moisten excessively dry soil that is not workable, and which is too dusty.
- B. Start of work covered in this Section constitutes Contractor's approval of all existing site conditions.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.



- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by the Engineer and replace with new planting soil.

### **3.02 SITE CONDITIONS**

- A. Planting restrictions: Plant during 1 of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date.
  - 1. Irrigated seed areas: Seed from ground thaw to July 31 and September 1 to October 15.
  - 2. Non-irrigated seed areas: Seed from March 15 to July 4 and September 1 to October 15.
  - 3. Pure Warm Season Grass Seed Areas: Seed from June 1 to August 15.
  - 4. Dormant Seeding Areas: Seed from October 15 to ground freeze.
  - 5. Per seed detail.
- B. Coordinate with Contractor's work requiring access to site over existing vegetation areas.
  - 1. No trucking or moving of equipment or materials shall be permitted over completed seed areas.
- C. Coordinate with installation of all underground system piping and outlets.
- D. Weather limitations:
  - 1. Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained.
  - 2. Apply products during favorable weather conditions according to manufacturer's written instructions.

### **3.03 EXISTING VEGETATION RENOVATION**

- A. Renovate existing vegetation.
- B. Renovate existing vegetation damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  - 1. Reestablish vegetation where settlement or washouts occur or where minor regrading is required.
  - 2. Install topsoil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory vegetation areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing vegetation.
- F. Prior to seeding, irrigate for a minimum of 2 weeks to allow germination of weed seeds.
  - 1. Apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.





2. Do not spray on a day when wind is detectable.
  3. Remove remaining vegetative matter.
  4. Repeat irrigation and herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.
- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil.
1. Install new planting soil to fill low spots and meet finish grades.
- J. Apply seed and protect with hydro mulch as required for new vegetation.
- K. Water newly planted areas and keep moist until new turf is established.

### **3.04 PREPARATION**

- A. Protect existing and new structures, fences, utilities, sidewalks, paving, curbs, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
1. Protect adjacent and adjoining areas from hydromulching overspray.
  2. Protect grade stakes set by others until directed to remove them.
  3. Protect landscaping and other features remaining as final work.
- B. Limit turf subgrade preparation to areas to be planted.
- C. Newly graded subgrades:
1. Loosen/scarify subgrade to a minimum depth of 6 inches.
  2. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
  3. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted the subgrade.
  4. Tolerances: Top of subgrade plus or minus 1 inch.
- D. Prepare subgrade and eliminate uneven areas and low spots.
1. Maintain lines, levels, profiles and contours.
  2. Make changes in grade gradual. Blend slopes into level areas.
- E. Do not prepare subgrade in areas of on-site plant preservation.
- F. Do not bury foreign material beneath areas to be seeded.
- G. Remove any contaminated subgrade.
1. Apply superphosphate fertilizer directly to subgrade before loosening.
    - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    - b. Mix lime with dry soil before mixing fertilizer.
  2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.





- a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
  - b. Reduce elevation of planting soil to allow for soil thickness of sod.
- H. Unchanged subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
  1. Remove existing grass, vegetation, and turf.
    - a. Do not mix into surface soil.
  2. Loosen surface soil to a depth of at least 6 inches.
    - a. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil.
    - b. Apply superphosphate fertilizer directly to surface soil before loosening.
  3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
  4. Legally dispose of waste material, including contaminated soils, grass, vegetation, and turf, off Owner's property.
- I. Finish grading:
  1. Grade seeding areas to a smooth, uniform surface plane with loose, uniformly fine texture.
  2. Grade to within plus or minus 1/2 inch of finish elevation.
  3. Roll and rake, remove ridges, fill depressions to meet finish grades, and ensure positive surface drainage.
  4. Maintain profiles and contour of subgrade.
  5. Limit finish grading to areas that can be planted in the immediate future.
- J. Rip topsoil that has been spread to a minimum depth of 8 inches in one direction using an agricultural ripper with tines spaced at no greater than 18 inches.
  1. Areas adjacent to walks, structures, curbs, etc., where the use of large mechanical equipment is difficult, shall be worked with smaller equipment or by hand.
- K. Manually spread topsoil close to plant materials and structures to prevent damage.
- L. Spread amendments, as determined by the soil test results or indicated on the Drawings, over the entire area to be seeded and incorporate into the top 6 inches of soil by disking or rototilling until a uniform mixture is obtained with no pockets of soil or amendments remaining.
- M. Restore fine grade with float drag to remove irregularities resulting from tilling operations.
  1. Float drag or rake in 2 directions.
  2. Remove any additional stones over 1 inch that have come to the surface.
  3. Perform drainage test by applying water with the irrigation system.
  4. Do not plant until the finished grade is reviewed by the Engineer.
  5. This review does not reduce Contractor's responsibility to provide a finished product that drains.
- N. Apply fertilizer, if necessary, after smooth raking of topsoil and prior to planting of seed.



1. Apply fertilizer at a rate as determined by the soil tests or indicated on the Drawings.
  2. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
  3. Mix thoroughly into upper 6 to 8 inches of soil.
- O. Lightly water to aid the dissipation of fertilizer.
- P. Remove any additional stones over 1 inch that have come to the surface.
- Q. Moisten prepared area before planting if soil is dry.
1. Water thoroughly and allow surface to dry before planting.
  2. Do not create muddy soil.
- R. Before planting, obtain Engineer's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- S. Tolerances: Top of topsoil plus or minus 1/2 inch.

### **3.05 PESTICIDE APPLICATION**

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations.
1. Coordinate applications with Owner's operations and others in proximity to the Work.
  2. Notify Owner before each application is performed.
- B. Post-emergent herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

### **3.06 SEED**

- A. Preparation for seeding:
1. Prior to seeding, if weeds exist, apply Round-Up herbicide per manufacturer's specifications after germination of weed seeds and at least 2 weeks prior to seeding.
  2. Do not spray on a day when wind is detectable.
  3. Remove remaining vegetative matter.
  4. Repeat herbicide application until no weeds are evident for 14 days after last herbicide application, as determined by the Engineer.
- B. Drill seeding:
1. Drill seed by means of a Brillion mechanical power-drawn drill seeders, or equal, to a maximum depth of 1/4-inch followed by packer wheels or drag chains to provide smooth finish.
  2. Seed at the rates given below.
  3. Seed in 2 passes at right angles to one another.
  4. Sow half the seed in each pass.
  5. Provide markers or other means to ensure that the successive seeded strips will overlap or be separated by a space no greater than the space between the rows planted by the equipment being used.



6. Do not seed during windy weather.
7. Restore fine grade after seeding as requested by the Engineer.
8. Remove irregularities by hand raking or rolling.
9. In areas inaccessible to a drill seeder, broadcast seed by hand in 2 opposite directions.
  - a. Rake in seed after broadcasting.
  - b. Do not broadcast seed during windy weather.
10. Seeding rates:
  - a. Seeding rates shall be as recommended by the seed supplier for drill seeded areas.
  - b. Hand and broadcast seeded areas shall receive 2 times the seeding rate indicated.
11. Do not seed areas in excess of that which can be mulched on same day.
12. Do not sow immediately following rain, when ground is too dry, frozen, or during windy periods.
13. Roll seeded area with roller not exceeding 100 pounds.
14. Immediately following seeding and compacting, apply mulch.
15. Sow seed with spreader or seed drill machine.
  - a. Do not broadcast or drop seed when wind velocity exceeds 5 miles per hour.
  - b. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
    - 1) Do not use wet seed or seed that is moldy or otherwise damaged.
    - 2) Do not seed against existing trees.
      - a) Limit extent of seed to outside edge of planting saucer.
16. Sow seed at a total rate as recommended by the seed supplier.
17. For any Broadcast seeded areas rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
18. Protect seeded areas with erosion-control mats where indicated on the Drawings; install and anchor according to manufacturer's written instructions.
19. In final preparations for seeding, use level board not less than 8 feet in length to ensure true and accurate grades.
20. Finish grade lawn areas to 2 inches below elevation of adjacent paving.
21. Do not take heavy objects, except lawn rollers, over areas that have been prepared for seeding.
22. Prior to seeding, Engineer shall accept areas for grade and compaction.

C. Seed establishment on slopes:

1. Protect seeded areas with slopes and swales exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
2. Roll fabric onto slopes without stretching or pulling.
3. Lay fabric smoothly on surface in direction of water flow.
4. Bury top end of each section in 6-inch deep excavated topsoil trench.
5. Provide 6-inch overlap of adjacent rolls.
6. Backfill trench and rake smooth, level with adjacent soil.
7. Secure outside edges and overlaps at 24-inch intervals with stakes.
8. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
9. For sides of ditches, lay fabric laps in direction of water flow.
10. Lap ends and edges minimum 6 inches.



D. Satisfactory seed areas:

1. Turf installations shall meet the following criteria as determined by the Engineer:
2. Acceptance for soil preparation (topsoil installation) and final grading shall be given by the Engineer upon satisfactory completion of each section or area prior to seeding.
3. Final completion for seeded areas shall be given by the Engineer as soon as there is an even stand of grass with germination over 100 percent of the site.
  - a. Warranty:
    - 1) Guarantee all seeding to be alive and healthy for 2 years following date of final completion by the Engineer.
    - 2) Seeded areas shall have an even stand of grass with germination, over 100 percent of the site within 45 days of seeding.
    - 3) All seeded grass areas are to be ensured of obtaining a satisfactory stand of growth.
    - 4) The total area occupied by bare spots larger than 0.25 square feet must not exceed 10 percent of the total seeded area.
    - 5) Maximum single bare spot size of irrigated seed 3 inches by 3 inches.
    - 6) Maximum single bare spot size of non-irrigated seed is 1 square foot.
    - 7) All seeded grass areas which do not meet the satisfactory stand of growth qualification shall be reseeded and mulched.
  - b. Re-seed areas that in the opinion of the Engineer do not meet the preceding standards.
4. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

E. Seeded area maintenance:

1. Maintain and establish seeded area by watering, noxious weed management, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable seeded area.
2. Roll, regrade, and replant bare or eroded areas and remulch.
3. Provide materials and installation the same as those used in the original installation.
  - a. Fill in as necessary soil subsidence that may occur because of settling or other processes.
    - 1) Replace materials and seeded area damaged or lost in areas of subsidence.
  - b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
  - c. Apply treatments as required to keep seeded area and soil free of pests and pathogens or disease.
    - 1) Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
4. Watering: Install and maintain temporary piping, hoses, and seeded area watering equipment to convey water from sources and to keep meadow uniformly moist.
5. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch.
  - a. Lay out temporary watering system to avoid walking over muddy or newly planted areas.



6. Water meadow with fine spray at a minimum rate of 1/2 inch per week or more for seed establishment for 6 weeks after planting or until seed establishment is determined by the Engineer (whichever is longer) unless rainfall precipitation is adequate.

### **3.07 MULCH**

- A. Straw mulching:
  1. After seeding, apply 2 tons of small grained straw per acre.
    - a. Spread straw to give a 1/2 inch to 1 inch thick layer of mulch (3 to 5 straws thick) and crimp in 2 to 3 inches with a mechanical crimper or other approved equipment.
  2. Hand crimping shall be employed in areas inaccessible to crimper, or where excessive slopes would cause unsatisfactory results.
  3. Crimping against the contour shall not be accepted.
  4. Apply water and tackifier with a fine spray immediately after each area has been mulched.
    - a. Saturate to 4 inches of soil.

### **3.08 HYDRO-MULCH**

- A. Hydro-mulching:
  1. Hydro-mulch all dormant seeded areas with a slurry mix containing additional tacifier.
  2. Utilize hydraulic equipment with nozzle adapted for hydraulic mulching with storage tanks having means of estimating volume used or remaining in the tank.
  3. Hydro-mulch shall consist of tacifier applied at a rate of 100 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
    - a. Hydro-mulch applied to dormant seeded areas shall consist of tacifier applied at a rate of 150 pounds per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,200 pounds per acre.
  4. Protect seeded areas with slopes not exceeding 1:4 by spreading straw mulch.
    - a. Spread uniformly at a minimum rate of 2 tons per acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas.
    - b. Spread by hand, blower, or other suitable equipment.
      - 1) Anchor straw mulch by crimping into soil with suitable mechanical equipment.
      - 2) Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gallons per 1,000 square feet.
        - a) Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas.
        - b) Immediately clean damaged or stained areas.
  5. Protect seeded areas from hot, dry weather or drying winds by applying hydro mulch and tackifier within 24 hours after completing seeding operations.
    - a. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch and roll surface smooth.



09

## HYDROSEED

### A. Installation:

1. Surface preparation:
  - a. Area to be hydroseeded to be weed free and have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of 2 to 4 inches.
  - b. Do not use any implements that will create an excessive amount of downward movement or clods on sloping areas.
  - c. Hydroseed bed may be prepared at time of completion of earth-moving work.
2. Application:
  - a. Mark test plots to calibrate equipment and rate of vehicle.
    - 1) Continue test operations until satisfied with performance of even, smooth application.
  - b. Apply seed with wood cellulose fiber at 500 pounds per acre.
    - 1) Do not allow seed to stay within slurry longer than 30 minutes.
  - c. Immediately after seeding, apply wood fiber mulch at 3,000 pounds per acre with a tackifier adhesive at 75 pounds per acre.
    - 1) Mixture to be sufficient green in color to determine coverage.
    - 2) Use nontoxic dye that is water-soluble.
  - d. Foot traffic on hydroseed is not permitted.
3. Slurry preparation:
  - a. Prepare slurry at project site, using potable water.
    - 1) Plant effluent is acceptable.
  - b. Dispose of any slurry that has not been used within 2 hours at a location off-site at Contractor's expense.

### B. Hydroseed watering:

1. Provide temporary watering system or apply water with a water truck acceptable to Engineer.
  - a. Plant effluent may be used for hydroseed watering.
  - b. Do not place irrigation lines on top of embankment slope.
2. Germination stage:
  - a. Initiate watering sequence within 24 hours after hydro-mulching planted areas. Leave water on long enough to moisten soil thoroughly to a depth of the fiber, taking care not to supersaturate or wash fiber or soil particles off the slopes. Observe irrigation system continually while in operation.
  - b. Contractor to repair all seed washing or erosion immediately.
  - c. Irrigate fiber and seed lightly and frequently to maintain optimum moisture content for maximum germination. Determine irrigation sequence according to air temperature, prevailing wind velocity, soil texture, orientation, and other logistical problems.
  - d. Keep soil moist at all times during germination period. Continue irrigation sequence until seedlings have grown beyond the germination stage, approximately 30 to 60 days.

### C. Establishment stage:

1. Reduce watering frequency while increasing duration of the water sufficiently to allow for maximum water penetration for the expanding root system. Take care not to cause erosion.
2. Precise watering reduction program to be determined by Contractor.





3. Hardening-off stage:
  - a. Reduce irrigation frequency while increasing the duration of each water cycle.
  - b. A specific watering program to be approved by Owner.
- D. Hydroseed fertilizer:
  1. Distributed uniformly over seed bed and incorporated into the soil. Incorporation may be part of the seed bed preparation or as part of the seeding operation, unless seed is broadcast.
    - a. If fertilizing is a part of the seed bed preparation, do not fertilize more than 15 days prior to seeding.
  2. Apply fertilizer at 250 pounds per acre.
- E. Hydroseed mowing:
  1. Contractor to mow seeded areas prior to spring germination.
- F. Hydroseed maintenance:
  1. Maintain hydroseed areas for 1 year following final acceptance.
  2. Maintenance involves watering, mowing, and any other activities required to establish and maintain the ground cover.

### **3.10 EROSION CONTROL BLANKETS**

- A. Preparation for erosion-control materials:
  1. Install erosion-control materials in accordance with manufacturers recommendations.
  2. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions.
    - a. Fasten as recommended by material manufacturer.
  3. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
  4. Erosion control hydroseeding to be applied to all stormwater ditches, stormwater pipe inlets, stormwater pipe outlets, and as indicated on the Drawings.
    - a. Hydroseeding shall be the last activity conducted by Contractor prior to project acceptance.
  5. Moisten prepared area before planting if surface is dry.
  6. Water thoroughly and allow surface to dry before planting.
  7. Do not create muddy soil.

### **3.11 CLEANUP AND PROTECTION**

- A. Promptly remove soil and debris created by turf work from paved areas.
  1. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly seeded areas from traffic.
  1. Maintain fencing and barricades throughout initial seed establishment.
- C. Remove nondegradable erosion-control measures after grass establishment period.



- D. During landscape installation:
  - 1. All areas shall be reasonably clean at the end of each workday.
  - 2. Sidewalks and other paved areas shall be swept or washed down as needed.
- E. Project completion:
  - 1. All debris, soil, and trash resulting from landscape operations shall be removed from the site.
  - 2. All paved areas shall be washed down.

END OF SECTION





## SECTION 03200

### CONCRETE REINFORCING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Reinforcing bars.
    - a. Carbon steel.
  - 2. Thread bars.
  - 3. Bar supports.
  - 4. Tie wires.
  - 5. Welded wire fabric.
  - 6. Mechanical reinforcing bar couplers.

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
  - 1. 318 - Building Code Requirements for Structural Concrete and Commentary.
  - 2. SP-66 - ACI Detailing Manual.
- B. American Iron and Steel Institute (AISI).
- C. American Welding Society (AWS):
  - 1. D1.4 - Structural Welding Code - Reinforcing Steel.
- D. ASTM International (ASTM):
  - 1. A123 - Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 3. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
  - 4. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
  - 5. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
  - 6. A1064 - Standard Specification of Carbon-Steel wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
- E. Concrete Reinforcing Steel Institute (CRSI):
  - 1. Manual of Standard Practice.
- F. ICC Evaluation Service (ICC-ES):
  - 1. AC133 - Acceptance Criteria for Mechanical Connector Systems for Steel Reinforcing Bars.
  - 2. AC347 - Acceptance Criteria for Headed Deformed Bars.



03

## DEFINITIONS

- A. Architectural concrete: Concrete surfaces that will be exposed to view in the finished work.
  - 1. Additionally, for purposes of this Section, includes:
    - a. Concrete surfaces that are designated to receive paints or coatings.
    - b. Exposed concrete in open basins, channels, and similar liquid containing structures: Surfaces shall be considered exposed to view if located above a line 2 feet below the normal operating water surface elevation in that structure.
- B. Bars: Reinforcement or reinforcing bars as specified in this Section.
- C. Evaluation Report: Report prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.
- D. Give away bars: Reinforcing bars that are not required by the Contract Documents, but are installed by the Contractor to provide support for the required reinforcing bars.
- E. Wire supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

## 1.04 SYSTEM DESCRIPTION

- A. The drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

## 1.05 SUBMITTALS

- A. General:
  - 1. Submit in accordance with Section 01330 - Submittal Procedures.
  - 2. Changes to reinforcement in Contract Documents:
    - a. Indicate in a separate letter submitted with shop drawings any changes to reinforcement indicated on the Drawings or specified.
    - b. Such changes will not be acceptable unless Engineer has accepted them in writing.
- B. Product data:
  - 1. Bar supports:
    - a. Wire bar supports:
      - 1) Schedule of support materials to be provided and locations of use.
    - b. Precast concrete bar supports ("dobies"):
      - 1) Manufacturer's data indicating compression strength of concrete and confirming dimensions and thickness(es), height(s) to be provided for each location where used.



2. Mechanical reinforcing bar couplers. For each type and/or series to be provided:
  - a. Evaluation Report documenting compliance with the requirements of ICC-ES AC133.
  - b. Details, properties, and dimensions of couplers. Include type or size identification, and bar size(s) and grade(s) for which the coupler is suitable.
  - c. Manufacturer's installation and testing instructions.
  - d. Manufacturer's statement that products installed in accordance with manufacturer's recommended procedures will develop strengths and limit slip as specified in this Section.
- C. Shop drawings:
  1. Reinforcement shop drawings:
    - a. Submit drawings showing bending and placement of reinforcement required by the Contract Documents.
    - b. Clearly indicate structures or portions of structures covered by each submittal.
      - 1) Submit reinforcement shop drawings for each structure as a complete package. Submittals addressing only a portion of a structure will be rejected and returned without review, unless such presentation is accepted by Engineer in advance.
    - c. Shop drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and ACI SP-66.
    - d. Use the same bar identification marks on bending detail drawings, placement drawings, and shipping tags.
    - e. Submittals consisting solely of reinforcing bar schedules, without accompanying placement drawings, will not be accepted unless accepted under prior written agreement with Engineer.
  2. Reinforcement placement drawings:
    - a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.
    - b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
    - c. Show splice locations.
    - d. Indicate locations of mechanical reinforcing couplers if used.
    - e.
  3. Reinforcement fabrication drawings:
    - a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.  
Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.
- D. Samples (when requested by Engineer):
  1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
  2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.



- E. Test reports:
  - 1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
    - a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
    - b. In such cases, submit certificates under the shop drawing submittal number with the letter "R" (for record date) appended to the end (e.g., of the reinforcement was submitted as 03200-002-1, deliver the associated mill certificate as submittal 03200-002-1R).
  - 2. Mechanical reinforcing bar couplers:
    - a. Current Evaluation Report confirming that couplers provide specified tension and compression strength and conform to specified limits on total slip within the coupler.
    - b. Certified copy of mill tests for heat(s) of steel incorporated into the reinforcing bar couplers shipped.
    - c. For threaded sleeve type couplers, heat treatment lot numbers for each shipment.
- F. Manufacturer's instructions:
  - 1. Mechanical reinforcing bar couplers:
    - a. Manufacturer's installation instructions.
    - b. Manufacturer's instructions for confirmation testing of couplers after reinforcing bars have been inserted into the couplers.
- G. Special procedures:
  - 1. Welding procedures conforming to AWS D1.4 for reinforcement to be field welded.
    - a. Procedures qualification record.
- H. Qualifications statements:
  - 1. Welder qualifications.
- I. Closeout documents:
  - 1. Field quality control and inspection reports.
  - 2. Field quality assurance special inspection and testing reports.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Packing and shipping:
  - 1. Deliver bars bundled and tagged with identifying tags.
- B. Acceptance at site:
  - 1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

## **1.07 SEQUENCING AND SCHEDULING**

- A. Bar supports:
  - 1. Do not place concrete until samples and product data for bar supports have been accepted by Engineer.



## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. Reinforcing bars:
  - 1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
  - 2. Reinforcing bars:
    - a. ASTM A615 Grade 60 deformed bars, including the following requirements.
      - 1) Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
      - 2) Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.
- B. Thread bars:
  - 1. Reinforcing bars conforming to ASTM A615, Grade 60 unless otherwise indicated on the Drawings, and having a continuous rolled-in pattern of thread-like deformations along entire length.
    - a. Substitution of shop-cut threads on regular ASTM A615 or A706 reinforcing bars is not permitted.
  - 2. Thread bar hardware, including nuts (hex and jamb), couplers, and washers (flat, spherical, and beveled):
    - a. Provided by same manufacturer as the threaded bars.
    - b. Capable of developing a load equal to at least 125 percent of the yield strength of the threaded bar.
  - 3. Manufacturers: One of the following or equal:
    - a. DYWIDAG-Systems International (DSI), DYWIDAG Threadbar®:
      - 1) Bar and accessories hot-dip galvanized in accordance with ASTM A123.
    - b. Williams Form Engineering Corp., Grade 75 all-thread rebar:
      - 1) Bar and accessories hot-dip galvanized in accordance with ASTM A153 to minimum 3 mils coating thickness.
- C. Bar supports:
  - 1. Wire supports:
    - a. All stainless steel bar supports:
      - 1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire conforming to ASTM A493, AISI Type 316.
    - b. Stainless steel protected bar supports:
      - 1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold--drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
      - 2) Stainless steel wire ends shall conform to ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
    - c. Bright basic wire bar supports.
      - 1) Conforming to CRSI Manual if Standard Practice, Class 3.



2. Plastic supports:
    - a. Manufacturers: The following or equal:
      - 1) Aztec Concrete Accessories.
  3. Deformed steel reinforcing bar supports:
    - a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
  4. Precast concrete bar supports ("dobies"):
    - a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
    - b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
    - c. Block dimensions:
      - 1) Height to provide specified concrete cover.
      - 2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.
  5. Stainless steel wire supports on stainless steel plates:
    - a. Type 304 stainless steel wire bar support chairs or bolsters supported on Type 304 stainless steel plates resting on the ground surface.
      - 1) Weld plates to at least 2 legs of wire support chairs.
- D. Tie wires:
1. General use: Black annealed steel wire, 16-gauge or heavier.
- E. Welded wire fabric reinforcement:
1. Material:
    - a. Carbon steel conforming to ASTM A1064.
  2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
  3. Fabric may be used in place of reinforcing bars if accepted by Engineer:
    - a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.
- F. Mechanical reinforcing bar couplers :
1. General:
    - a. Only products conforming to the requirements of ACI 318 for mechanical splices, and holding a current Evaluation Report that documents the following performance characteristics, will be considered for use.
    - b. Strength of coupler: Capable of developing tension and compression strength not lower than the lesser of the following:
      - 1) ACI 318 "Type 2" units: In static tension and compression:
        - a) Minimum 125 percent of the ASTM-specified minimum yield strength of the reinforcement being spliced or terminated.
        - b) Minimum 100 percent of the ASTM-specified minimum ultimate strength of the reinforcement being spliced or terminated.



- c. Slip of reinforcing bars within coupler: Total slip of the reinforcing bars within the splice sleeve limited as follows:
  - 1) For bar sizes #14 and smaller, elongation between gauge points measured clear of the splice sleeve not exceeding 0.010 inches after coupler has been loaded to a tension of 30,000 pounds per square inch and load relaxed to a tension of 3,000 pounds per square inch.
- d. Fabrication:
  - 1) Threaded joints:
    - a) Provide threaded ends designed so that cross-threading of bars will not occur during assembly.
    - b) Fabricate male ends for female couplers using coupler manufacturer's bar threading equipment to ensure proper taper and thread engagement.
  - 2) Mark each sleeve with heat treatment lot number.
- 2. Couplers: Threaded - Reinforcing bar splice at construction joints.
  - a. Steel sleeve butt splice with tapered internal threads in forged or swaged head, and nailing flange for attaching to forms. Provide with matching, tapered male-threaded dowels for insertion and tightening into threaded sleeve after form removal.
    - 1) Provide sleeve with factory-installed plugs to prevent concrete mortar from entering internally threaded coupler.
    - 2) Provide optional clipped nailing flanges as required to maintain minimum specified concrete cover over all surfaces of coupler.
  - b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
  - c. Manufacturers: One of the following or equal:
    - 1) Dayton Superior, DBDI Splice System.
    - 2) ERICO-Pentair, Lenton Form Saver.
- 3. Couplers: Threaded - reinforcing bar splice:
  - a. Steel sleeve butt splice with tapered internal threads at each end for joining to matching tapered male threads on reinforcing bars.
  - b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
  - c. Manufacturers: One of the following, or equal:
    - 1) Dayton Superior: Taper-Lock System.
    - 2) ERICO-Pentair: Lenton Taper Threaded Splicing System.
    - 3)
- 4. Couplers: Threaded - All thread rod to reinforcing bar:
  - a. Steel sleeve butt splice with tapered internal threads on one end for joining to matching tapered male threads on reinforcing bars, and straight internal threads at opposite end for joining to matching straight male threads on all-thread rods.
  - b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
  - c. Manufacturers: The following or equal:
    - 1) ERICO-Pentair, Lenton Bolt Coupler - S4 or S5 Series.

## 2.02 FABRICATION

- A. Shop fabrication and assembly:
  - 1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.





2. Bend bars cold. Use bending collars to develop the recommended bend radius.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.
5. Bars to be fitted with mechanical couplers:
  - a. Fabricate threaded ends for connections in shop using manufacturer's recommended tools. Field fabrication is not allowed.
  - b. Cut ends square.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions:
  1. Reinforcing bars and welded wire reinforcement:
    - a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.
  2. Welded wire fabric:
    - a. Verify that sheets are not curled or kinked before or after installation.

### **3.02 PREPARATION**

- A. Surface preparation:
  1. Reinforcing bars - uncoated:
    - a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
    - b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.
    - c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

### **3.03 INSTALLATION**

- A. Reinforcing bars: General:
  1. Field-cutting of reinforcing bars is not permitted.
  2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.
- B. Placing reinforcing bars:
  1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
  2. Tolerances for placement and minimum concrete cover: As listed in Table 1.





**Table 1 - Reinforcement Placing Tolerances**

<b>Member</b>	<b>Tolerance on Reinforcement Location <sup>(1)</sup></b>	<b>Tolerance on Minimum Concrete Cover <sup>(1,2)</sup></b>
Slabs, beams, walls and columns except as noted below:		
10 inches thick and less	$\pm 3/8$ inch	- 3/8 inch
More than 10 inches thick	$\pm 1/2$ inch	- 1/2 inch
Formed soffits:	As noted above	- 1/4 inch
Longitudinal location of bends and ends of reinforcement:		
Conditions not listed below:	$\pm 2$ inches	- 1/2 inch
At discontinuous ends of brackets and corbels	$\pm 1/2$ inch	- 1/4 inch
At discontinuous ends of other members:	$\pm 1$ inch	- 1/2 inch
Notes: (1) $\pm$ indicates "plus or minus;" - indicates "minus;" + indicates "plus." (2) Tolerance on cover is limited as noted, but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.		

3. Spacing between bars:

- a. Minimum clear spacing between bars in a layer:
  - 1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
- b. Minimum clear spacing between bars in 2 or more parallel layers:
  - 1) Place bars in upper layers directly above bars in lower layers.
  - 2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
- c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.

4. Lap splices for bars:

- a. Lap splice locations and lap splice lengths: as indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.
- b. Unless otherwise specifically indicated on the Drawings (and noted as "non-contact lap splice"), install bars at lap splices in contact with each other and fasten together with tie wire.
- c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
- d. Stagger lap splices where indicated on the Drawings.
- e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.



C. Reinforcing supports:

1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
  - a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.
2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
3. Do not use "give away bars" that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.
4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

Table 2 - Reinforcement Support Materials		
Case	Location	Material
a.	Concrete placed over earth and concrete seal slabs ("mud mats"):	Precast concrete bar supports or Stainless steel wire supports on stainless steel plates.
b.	Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings):	All stainless steel bar supports.
c.	Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work	All stainless steel bar supports.
d.	Concrete placed against forms and exposed to interior equipment/piping areas in the finished work	All stainless steel bar supports.
e.	Between mats of reinforcement, and fully embedded within a concrete member	Bright basic wire bars supports, or deformed steel reinforcing bars.

D. Tying of reinforcing:

1. Fasten reinforcement securely in place with wire ties.
2. Tie reinforcement at spacings sufficient to prevent shifting.
  - a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
3. Tie slab bars at every intersection around perimeter of slab.
4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:



**Table 3 - Maximum Spacing of Tie Wires for Reinforcement**

<b>Bar Size</b>	<b>Slab Bar Spacing (inches)</b>	<b>Wall Bar Spacing (inches)</b>
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

5. After tying:
  - a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
  - b. Remove tie wire clippings from inside forms before placing concrete.
- E. Welded wire fabric reinforcement:
  1. Install only where indicated on the Drawings or accepted in advance by Engineer.
  2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
  3. Straighten welded wire fabric to make sheets flat in the Work.
  4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
    - a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to Engineer.
  5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
  6. Lap splice welded wire fabric as indicated on the Drawings.
    - a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.
- F. Welding reinforcing bars:
  1. Weld reinforcing bars only where indicated on the Drawings or where acceptance is received from Engineer prior to welding.
  2. Perform welding in accordance with AWS D1.4 and welding procedures accepted by Engineer.
    - a. Conform to requirements for minimum preheat and interpass temperatures.
  3. Submit:
    - a. Welding procedures specification.
    - b. Procedures qualification record.
    - c. Welder qualification test record.
  4. Do not tack weld reinforcing bars except where specifically indicated on the Drawings.
- G. Reinforcing bar mechanical couplers:
  1. Install only at locations indicated on the Drawings or where prior approval has been obtained from Engineer.



2. Install in accordance with manufacturer's instructions and requirements of Evaluation Report.
  - a. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.
  - b. After assembly of the splice, tighten using torque load not less than that recommended by the manufacturer.
3. Unless greater cover is indicated on the Drawings, provide clear cover from surface of concrete to outside face of couplers that is not less than the minimum concrete cover specified for typical reinforcement.
  - a. If cover is less than required, contact Engineer for evaluation of conditions before modifying locations of bars or placing concrete.
  - b. Modifications to maintain or provide required concrete cover, such as addition of concrete; re-positioning of stirrups, ties, etc., may be completed only after approval by Engineer.

### **3.04 FIELD QUALITY CONTROL**

- A. Provide quality control for the Work of this Section as specified in Section 01450 - Quality Control.
- B. Field inspections and testing:
  1. Submit records of inspections and testing to Engineer in electronic format within 24 hours after completion.
- C. Manufacturer's services:
  1. Furnish manufacturer's technical representative to conduct jobsite training regarding proper storage, handling, and installation of mechanical reinforcing bar couplers and bar end anchors for personnel who will perform the installation. Engineer may attend training session.

### **3.05 FIELD QUALITY ASSURANCE**

- A. Provide quality assurance as specified in Section 01450 - Quality Control.
- B. Special inspections and tests:
  1. Provide as specified in Section 01455 - Special Tests and Inspections.
  2. Frequency of inspections:
    - a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01410 - Regulatory Requirements.
  3. Preparation:
    - a. Review Drawings and Specification for the Work to be observed.
    - b. Review approved submittal and shop drawings.
  4. Inspections: Special inspection shall include, but is not limited to, the following items.
    - a. Reinforcement: General:
      - 1) Type (material) and location of reinforcement supports.
      - 2) Bar material/steel grade and bar size.
      - 3) Location, placement, and spacing of bars.
      - 4) Clear concrete cover over reinforcement.
      - 5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings.)



- 6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
- 7) Reinforcement tied in position and tie wire legs turned inward toward the center of the concrete section.
- b. Reinforcement: Welding:
  - 1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
  - 2) Provide periodic inspection for:
    - a) Weldability of reinforcement other than ASTM A706.
    - b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
  - 3) Provide continuous inspection for:
    - a) Other welds.
    - b) Welds at mechanical reinforcing bar couplers and end anchors.
  - 4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
5. Mechanical reinforcing bar couplers:
  - a. Special inspection shall include, but is not limited to, the following items:
    - 1) Coupler model and identification.
    - 2) Couplers are installed in accordance with the requirements of the Engineering Report for each product.
    - 3) Confirmation of the following:
      - a) Grade and size of reinforcing bars.
      - b) Position of couplers and end anchors.
      - c) Insertion length of reinforcement.
      - d) Tightening of bars in the couplers and end anchors.
6. Records of inspections:
  - a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
  - b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspections.

### **3.06 NON-CONFORMING WORK**

- A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION





## SECTION 03300

### CAST-IN-PLACE CONCRETE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Cast-in-place concrete.

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
1. 305 - Hot Weather Concreting Standard.
  2. 306 - Cold Weather Concreting Standard.
  3. 318 - Building Code Requirements for Structural Concrete and Commentary.
  4. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
  5. Manual of Concrete Practice.
- B. ASTM International (ASTM):
1. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
  2. C33 - Standard Specification for Concrete Aggregates.
  3. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
  4. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
  5. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
  6. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
  7. C94 - Standard Specification for Ready-Mixed Concrete.
  8. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
  9. C117 - Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing.
  10. C123 - Standard Test Method for Lightweight Particles in Aggregate.
  11. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
  12. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
  13. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
  14. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
  15. C150 - Standard Specification for Portland Cement.
  16. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
  17. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
  18. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
  19. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.



20. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
21. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
22. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
23. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
24. C494 - Standard Specification for Chemical Admixtures for Concrete.
25. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
26. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
27. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
28. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
29. D75 - Standard Practice for Sampling Aggregates.
30. D2103 - Standard Specification for Polyethylene Film and Sheeting.

C. NSF International (NSF):

1. 61 - Drinking Water System Components - Health Effects.

### 1.03 DEFINITIONS

- A. Alkali: Sum of sodium oxide and potassium oxide calculated as sodium oxide.
- B. Cementitious materials: Portland cement and fly ash.
- C. Cold weather: A period when for more than 3 consecutive days, the average daily outdoor temperature drops below 40 degrees Fahrenheit. The average daily temperature is the average of the highest and lowest temperatures during the period from midnight to midnight. When temperatures above 50 degrees Fahrenheit occur during more than half of any 24-hour duration, the period shall no longer be regarded as cold weather.
- D. Cold weather concreting: Operations for placing, finishing, curing, and protection of concrete during cold weather.
- E. Green concrete: Concrete with less than 100 percent of the specified strength.
- F. Hairline crack: Crack with a crack width of less than 4 thousandths of an inch.
- G. Hot weather: A period when project conditions such as low humidity, high temperature, solar radiation, and high winds, promote rapid drying of freshly placed concrete.
- H. Hot weather concreting: Operations for placing, finishing, curing, and protection of concrete during hot weather.





## 1.04 SYSTEM DESCRIPTION

### A. Performance requirements:

1. General:
  - a. Except as otherwise specified, provide concrete composed of portland cement, fly ash, fine aggregate, coarse aggregate, admixtures and water so proportioned and mixed as to produce plastic, workable mixture in accordance with requirements as specified in this Section and suitable to specific conditions of placement.
  - b. Proportion materials in a manner that will secure lowest water-cementitious materials ratio that is consistent with good workability, plastic and cohesive mixture, and a mixture that is within specified slump range.
  - c. Proportion fine and coarse aggregates in manner such as not to produce harshness in placing or honeycombing.
2. It is the intent of this Section to secure for every part of the Work concrete with homogeneous mixture, which when hardened will have required strength, watertightness, and durability:
  - a. It is recognized that some surface hairline cracks and crazing will develop in the concrete surfaces.
  - b. Construction, contraction, and expansion joints have been specified and positioned in structures as indicated on the Drawings, and curing methods specified, for purpose of reducing number and size of cracks, due to normal expansion and contraction expected from specified concrete mixes.
  - c. Repair cracks which develop in walls or slabs and repair cracks which show any signs of leakage until all leakage is stopped.
  - d. Pressure inject visible cracks, other than hairline cracks and crazing, in following areas with epoxy as specified in Section 03931 - Epoxy Injection System:
    - 1) Floors and walls of water bearing structures.
    - 2) Walls and overhead slabs of passageways or occupied spaces, outsides of which are exposed to weather or may be washed down and are not specified to receive separate waterproof membrane.
    - 3) Other items not specified to receive separate waterproof membrane: Slabs over water channels, wet wells, reservoirs, and other similar surfaces.
  - e. Walls or slabs, as specified above, that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy: Seal on water or weather side by coatings of surface sealant system, as specified in this Section.
  - f. Pressure injection and sealing: Continue as specified above until structure is watertight and remains watertight for not less than 1 year after final acceptance or date of final repair, whichever occurs later in time.
3. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI 318, ACI 350, Manual of Concrete Practices, and recommended practices.



05

## SUBMITTALS

- A. Cement mill tests:
  - 1. Include alkali content representative of each shipment of cement for verification of compliance with specified requirements.
  - 2. Provide mill test reports dated not more than 90 days before the date of submittal.
- B. Cold weather concreting:
  - 1. Procedures for the production, transportation, placement, protection, curing, and temperature monitoring for concrete during cold weather.
  - 2. Procedures to be implemented upon abrupt changes in weather conditions or equipment failures.
- C. Concrete mixes: Full details, including mix design calculations for concrete mixes proposed for use for each class of concrete:
  - 1. Include information on correction of batching for varying moisture contents of fine aggregate.
  - 2. Source quality test records with mix design submittal:
    - a. Include calculations for required compressive strength ( $f'_{cr}$ ) based on source quality test records.
- D. Concrete aggregate tests: Certified copies in triplicate of commercial laboratory tests not more than 90 days old of all samples of concrete aggregates:
  - 1. Coarse aggregate:
    - a. Abrasion loss.
    - b. Clay lumps and friable particles.
    - c. Coal and lignite.
    - d. Materials finer than 200 sieve.
    - e. Reactivity.
    - f. Shale and chert.
    - g. Soundness.
  - 2. Fine aggregate:
    - a. Clay lumps.
    - b. Color.
    - c. Decantation.
    - d. Reactivity.
    - e. Shale and chert.
    - f. Soundness.
- E. Drying shrinkage test data.
- F. Fine or coarse aggregate batched from more than 1 bin: Analyses for each bin, and composite analysis made up from these, using proportions of materials to be used in mix.
- G. Fly ash Certificate of Compliance: Identify source of fly ash and certify compliance in accordance with ASTM C618.
- H. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Corrective measures for use prior to placing concrete.



- I. Hot weather concreting: Procedures for production, placement, finishing, curing, protection, and temperature monitoring for concrete during hot weather and appropriate corrective measures.
- J. Heating equipment for cold weather concreting: Information on type of equipment used for heating materials and new concrete in process of curing during excessively cold weather.
- K. Information on mixing equipment.
- L. Product data: Submit data completely describing products.
- M. Sequence of concrete placing: Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements.
- N. Sieve analysis: Submit sieve analyses of fine and coarse aggregates being used in triplicate at least every 3 weeks and at any time there is significant change in grading of materials.
- O. Trial batch test data:
  - 1. Submit data for each test cylinder.
  - 2. Submit data that identifies mix and slump for each test cylinder.
- P. Weather monitoring: Records of:
  - 1. Relative humidity.
  - 2. Site ambient temperature.
  - 3. Wind speed.
- Q. Temperature of freshly placed concrete.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Packing and shipping:
  - 1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
  - 2. Deliver and store packaged materials in original containers until ready for use.
  - 3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.
- B. Acceptance at site: Reject material containers or materials showing evidence of water or other damage.

#### **1.07 PROJECT CONDITIONS**

- A. Environmental requirements:
  - 1. Monitoring weather conditions:
    - a. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.



- b. Measure and record temperature of fresh concrete. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature of concrete.
- c. Monitor and keep records of the weather forecast starting at least 48 hours prior to placing concrete in order to allow enough time for taking appropriate measures pertaining to Hot or Cold weather concreting.
- 2. Hot weather concreting:
  - a. Initiate evaporation control measures when concrete and air temperatures, relative humidity of the air, and the wind velocity have the capacity to evaporate water from a free surface at a rate that is equal to or greater than 0.2 pounds per square feet per hour. Determine evaporation rate using the Menzel Formula and monograph in ACI 305 3.1.3.
  - b. When ambient air temperature is above 85 degrees Fahrenheit: Prior to placing concrete, cool forms and reinforcing steel by water cooling to below 90 degrees Fahrenheit.
  - c. Monitor weather conditions at the site including air temperature, humidity, and wind speed, to assess the need for evaporation control measures begin monitoring site conditions no later than 1 hour before the start of concrete placement. Continue to monitor site conditions at intervals of 30 minutes until concrete curing has begun.
  - d. Temperature of concrete mix at time of placement: Keep temperature below 90 degrees Fahrenheit by methods which do not impair quality of concrete.
  - e. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Take corrective measures to minimize rapid water loss from concrete:
  - f. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature around concrete.
- 3. Cold weather concreting:
  - a. Concrete placed below ambient air temperature of 45 degrees Fahrenheit and falling or below 40 degrees Fahrenheit:
    - 1) Make provision for heating water.
  - b. Follow recommendations of ACI 306 for preparation, placement, and protection of concrete during cold weather.
  - c. If materials have been exposed to freezing temperatures to degree that any material is below 35 degrees Fahrenheit: Heat such materials.
  - d. Heating water, cement, or aggregate materials:
    - 1) Do not heat in excess of 160 degrees Fahrenheit.
  - e. Protection of concrete in forms:
    - 1) Do not remove forms from concrete when outside ambient air temperature is below 50 degrees Fahrenheit until concrete has attained its minimum specified compressive strength. Evidence of strength shall be based on by testing of cylinders stored in the field under equivalent conditions to those at the concrete structure.
    - 2) Protect by means of covering with tarpaulins, or other acceptable covering acceptable to Engineer.
    - 3) Provide means for circulating warm moist air around forms in manner to maintain temperature of 50 degrees Fahrenheit for at least 5 days.



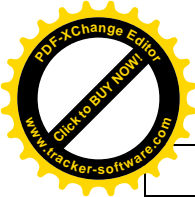
## 1.08 SEQUENCING AND SCHEDULING

- A. Schedule placing of concrete in such manner as to complete any single placing operation to construction or expansion joint.

## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. Admixtures:
  - 1. General:
    - a. Do not use admixtures of any type, except as specified, unless written acceptance has been obtained from the Engineer.
    - b. Admixtures shall be compatible with concrete and other admixtures. Admixtures other than pozzolans shall be the products of a single manufacture to ensure compatibility.
    - c. Do not use admixtures containing chlorides calculated as chloride ion in excess of 0.5 percent by weight of cement.
    - d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
  - 2. Air entraining admixture:
    - a. Provide concrete with 5 percent, within 1 percent, entrained air of evenly dispersed air bubbles at time of placement.
    - b. In accordance with ASTM C260.
  - 3. Water reducing admixture:
    - a. May be used at the Contractor's option.
    - b. In accordance with ASTM C494, Type A or Type D.
    - c. Not contain air-entraining agents.
    - d. Liquid form before adding to the concrete mix.
    - e. No decrease in cement is permitted as result of use of water reducing admixture.
  - 4. Super-plasticizers: Are not to be used without acceptance by Engineer.
- B. Aggregate:
  - 1. General:
    - a. Provide concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of allowable amounts specified.
    - b. Grade aggregate in accordance with ASTM C136 and D75.
    - c. Provide unit weight of fine and coarse aggregate that produces in place concrete with weight of not less than 140 pounds per cubic foot.
    - d. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
  - 2. Fine aggregate:
    - a. Provide fine aggregate for concrete or mortar consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
    - b. Do not provide aggregate having deleterious substances in excess of following percentages by weight of contaminating substances.
      - 1) In no case shall total exceed percent listed.



<u>Item</u>	<u>Test Method</u>	<u>Percent</u>
Removed by decantation (dirt, silt, etc.)	ASTM C117	3
Shale or Chert	ASTM C123 ASTM C295*	1 1
Clay Lumps	ASTM C142	1
* Test Method C123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C295 is used to identify which of the lightweight particles are shale or chert. If the results of Test Method C123 are less than 1 percent, Test Method C295 is not required.		

- c. Except as otherwise specified, grade fine aggregate from coarse to fine in accordance with ASTM C33.
3. Coarse aggregate:
  - a. Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances.
  - b. Not exceeding 15 percent by weight, of thin or elongated pieces having length greater than 5 times average thickness.
  - c. Deleterious substances: Not in excess of following percentages by weight, and in no case having total of all deleterious substances exceeding 2 percent.

<u>Item</u>	<u>Test Method</u>	<u>Percent</u>
Shale or chert	ASTM C123 ASTM C295*	1.25 1
Coal and lignite	ASTM C123	1/4
Clay lumps and friable particles	ASTM C142	1/4
Materials finer than Number 200 sieve	ASTM C117	1/2**
* Test Method C123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C295 is used to identify which of the lightweight particles are shale, chert, coal, or lignite. If the results of Test Method C123 are less than 1.25 percent (the minimum combined percentage of shale, chert, coal and lignite), Test Method C295 is not required.		
** Except when material finer than Number 200 sieve consists of crusher dust, maximum amount shall be 1 percent.		

- d. Grading:
  - 1) Aggregate for Class A, B, C, and D concrete: In accordance with ASTM C33, Size Number 57, except as otherwise specified or authorized in writing by the Engineer.
  - 2) Aggregate for Class CE concrete for encasement of electrical conduits:
    - a) Graded in accordance with ASTM C33, Size Number 8.



- C. Concrete sealer:
  - 1. Manufacturers: One of the following or equal:
    - a. Euclid Chemical Co., Diamond Hard.
    - b. L&M Construction Chemicals, SealHard.
- D. Conduit encasement coloring agent:
  - 1. Color: Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
  - 2. Manufacturers: One of the following or equal:
    - a. Davis Co., #160 Brick Red.
    - b. Euclid Chemical Co., Increte Division, "Colorcrete Brick Red."
  - 3. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.
- E. Evaporation retardant:
  - 1. Manufacturers: One of the following or equal:
    - a. BASF, MasterKure ER 50.
    - b. Euclid Chemical Co., Eucobar.
- F. Fly ash:
  - 1. Fly ash in accordance with ASTM C618, Class F, may be used in concrete made with Type II portland cement.
  - 2. Maximum of 15 percent by weight of fly ash to total weight of cementitious materials.
    - a. The total weight of cementitious materials shall not be less than minimum cementitious materials listed in Table A.
  - 3. Do not use in concrete made with portland-pozzolan cement.
  - 4. Loss on ignition: Not exceed 4 percent.
- G. Keyway material: Steel, plastic, or lumber.
- H. Nonslip abrasive:
  - 1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
  - 2. Manufacturers: One of the following or equal:
    - a. Abrasive Materials, Inc.
    - b. Euclid Chemical Co., Flexolith Summer Grade.
- I. Portland cement:
  - 1. Conform to specifications and tests in accordance with ASTM C150, Types II or III, low alkali, except as specified otherwise.
  - 2. Have total alkali containing not more than 0.60 percent.
  - 3. Exposed concrete in any individual structure: Use only one brand of portland cement.
  - 4. Cement for finishes or repairs: Provide cement from same source and of same type as concrete to be finished or repaired.
- J. Sheet membrane for curing:
  - 1. Polyethylene film:
    - a. In accordance with ASTM C171.
    - b. Color: White.





- c. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
  - d. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.
- K. Sprayed membrane curing compound: Clear type with fugitive dye in accordance with ASTM C309, Type 1D.
- L. Surface sealant system:
  - 1. Manufacturers: One of the following or equal:
    - a. Euclid Chemical Co., Vandex Super.
    - b. Kryton International, Inc., Krystol T1.
    - c. Xypex Chemical Corp., Xypex Concentrate.
- M. Water:
  - 1. Water for concrete, washing aggregate, and curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
  - 2. Chlorides and sulfate ions:
    - a. Water for conventional reinforced concrete: Use water containing not more than 1,000 milligrams per liter of chlorides calculated as chloride ion, nor more than 1,000 milligrams per liter of sulfates calculated as sulfate ion.
    - b. Water for prestressed or post-tensioned concrete: Use water containing not more than 650 milligrams per liter of chlorides calculated as chloride ion, or more than 800 milligrams per liter of sulfates calculated as sulfate ion.

## **2.02 EQUIPMENT**

- A. Mixing concrete:
  - 1. Mixers may be of stationary plant, paver, or truck mixer type.
  - 2. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material.
  - 3. Mixing equipment:
    - a. Capable of combining aggregates, cementitious materials, and water within specified time into thoroughly mixed and uniform mass and discharging mixture without segregation.
    - b. Maintain concrete mixing plant and equipment in good working order and operated at loads, speeds, and timing recommended by manufacturer or as specified.
    - c. Proportion cementitious materials and aggregate by weight.
- B. Machine mixing:
  - 1. Batch plant shall be capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.
  - 2. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.





3. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
  4. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
  5. Retempering of concrete will not be permitted.
  6. Discharge entire batch before recharging.
  7. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
  8. Mixers:
    - a. Perform mixing in batch mixers of acceptable type.
    - b. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
    - c. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
      - 1) Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
- C. Transit-mixed concrete:
1. Mix and deliver in accordance with ASTM C94.
  2. Total elapsed time between addition of water at batch plant and discharging completed mix:
    - a. Not to exceed 90 minutes.
    - b. Elapsed time at project site shall not exceed 30 minutes.
  3. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
  4. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.
  5. Continuously revolve drum after it is once started until it has completely discharged its batch:
    - a. Do not add water until drum has started revolving.
    - b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. The Contractor will not be entitled to additional compensation because of such increase or decrease.
- D. Other types of mixers: In case of other types of mixers, mixing shall be as follows:
1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
  2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
  3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

**MIXES****A. Measurements of materials:**

1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
5. Weighing cementitious materials:
  - a. Weigh cementitious materials separately.
  - b. Cement in unbroken standard packages (sacks): Need not be weighed.
  - c. Weigh bulk cementitious materials and fractional packages.
6. Measure mixing water by volume or by weight.

**B. Concrete proportions and consistency:**

1. Provide concrete that can be worked readily into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on surface.
2. Prevent unnecessary or haphazard changes in consistency of concrete.
3. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete Classes, with exception of Class CE.
4. Aggregate:
  - a. Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operation.
5. Maximum concrete mix water to cementitious materials ratio, minimum cementitious materials content, and slump range: Conform to values specified in Table A in this Section.
6. Concrete batch weights: Control and adjust to secure maximum yield. At all times, maintain proportions of concrete mix within specified limits.
7. Mix modification: If required, by the Engineer, modify mixture within limits set forth in this Section.

**C. Concrete mixes:**

1. Proportioning of concrete mix: Proportion mixes based on required compressive strength  $f'_{cr}$ .
2. Mixes:
  - a. Adjusting of water: After acceptance, do not change mixes without acceptance by Engineer, except that at all times adjust batching of water to compensate for free moisture content of fine aggregate.
  - b. Total water content of each concrete class: Not exceed those specified in Table A in this Section.
  - c. Checking moisture content of fine aggregate: Furnish satisfactory means at batching plant for checking moisture content of fine aggregate.
3. Change in mixes: Submit new mix design and perform new trial batch and test program as specified in this Section.



D. Classes of concrete:

1. Provide concrete consisting of 5 classes: Classes A, B, C, D, and CE. Use where specified or indicated on the Drawings.
2. Weight of concrete classes: Provide classes of concrete having minimum weight of 145 pounds per cubic foot.
3. Class B concrete: Class B concrete may be substituted for Class A concrete, when high-early strength concrete is needed in areas specifically accepted by the Engineer and that do not require sulfate resistant concrete.
4. Class C concrete: Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
5. Class D concrete: Use Class D for precast concrete items.
6. Class CE concrete: Use Class CE for electrical conduit encasements.
7. All other concrete, unless specified or otherwise indicated on the Drawings: Use Class A concrete.
8. Pumped concrete: Provide pumped concrete that complies with all requirements of this Section.
9. Do not place concrete with slump outside limits indicated in Table A.
10. Classes:
  - a. Classes A, C, D, and CE concrete: Make with Type II low alkali portland cement.
  - b. Class B concrete: Make with Type III low alkali portland cement.
  - c. Admixtures: Provide admixtures as specified in this Section.

E. Air entraining admixture:

1. Add agent to batch in portion of mixing water.
2. Batch solution by means of mechanical batcher capable of accurate measurement.

## 2.04 SOURCE QUALITY CONTROL

A. Tests:

1. Trial batches:
  - a. After concrete mix designs have been accepted by Engineer, have trial batches of the accepted Class A, Class B, and Class D concrete mix designs prepared by testing laboratory acceptable to the Engineer.
  - b. Prepare trial batches using cementitious materials and aggregates proposed to be used for the Work.
  - c. Prepare trial batches with sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient test cylinders.
  - d. Test cylinders: Provide cylinders having 6-inch diameter by 12-inch length and that are prepared in accordance with ASTM C31 for tests specified in this Section.
  - e. Determine slump in accordance with ASTM C143.
  - f. Test cylinders from trial batch:
    - 1) Test 8 cylinders for compressive strength in accordance with ASTM C39:
      - a) Test 4 cylinders at 7 days and 4 at 28 days.



- b) Establish ratio between 7 day and 28 day strength for mix. 7-day strength may be taken as satisfactory indication of 28-day strength provided effects on concrete of temperature and humidity between 7 day and 28 day are taken into account.
    - 2) Average compressive strength of 4 test cylinders tested at 28 days: Equal to or greater than required average compressive strength ( $f'_{cr}$ ) on which concrete mix design is based.
  - g. If trial batch tests do not meet specified requirements for slump, strength, workability, consistency, drying shrinkage, and finishing, change concrete mix design proportions and, if necessary, source of aggregate.
    - 1) Perform additional trial batches and tests until an acceptable trial batch is produced that meets requirements of this Section.
  - h. Perform test batches and tests required to establish trial batches and acceptability of materials without change in Contract Price.
  - i. Do not place concrete until the concrete mix design and trial batch have been accepted by Engineer.
2. Required average compressive strength:
- a. Determine required average compressive strength ( $f'_{cr}$ ) for selection of concrete proportions for mix design, for each class of concrete, using calculated standard deviation for its corresponding specified compressive strength ( $f'_c$ ) in accordance with ACI 318 and ACI 350.
  - b. When test records of at least 30 consecutive tests that span period of not less than 45 calendar days are available, establish standard deviation as in accordance with ACI 318 and ACI 350 and as modified in this Section.
  - c. Provide test records from which to calculate standard deviation that represent materials, quality control procedures, and conditions similar to materials, quality control procedures, and conditions expected to apply in preparation of concrete for the Work.
  - d. Provide test records with materials and proportions that are more restricted than those for the Work.
  - e. Specified compressive strength ( $f'_c$ ) of concrete used in test records: Within 1,000 pounds per square inch of that specified for the Work.
  - f. When lacking adequate test records for calculation of standard deviation meeting requirements, determine required average compressive strength  $f'_{cr}$  from following Table B.

<b>TABLE B</b>	
<b>REQUIRED AVERAGE COMPRESSION STRENGTH</b>	
<b>Specified Compressive Strength <math>f'_c</math> (pounds per square inch)</b>	<b>Required Average Compressive Strength <math>f'_{cr}</math> (pounds per square inch)</b>
Less than 3,000	$f'_c + 1,000$
3,000 to 5,000	$f'_c + 1,200$
Over 5,000	$1.10f'_c + 700$

3. Aggregate:
- a. Testing of concrete aggregate is at Contractor's expense.
  - b. Provide test reports representing samples of materials taken and tested at the following times:
    - 1) Not more than 60 days prior to the date on the proposed materials for concrete mixes.



- 2) Not more than 60 days prior to any change in the source of aggregates, including suppliers and/or quarries.
- 3) Whenever there is a significant change in aggregate quality or gradation from a previously submitted and accepted source.
- c. Sample aggregate in accordance with ASTM D75.
- d. Fine and coarse aggregates:
  - 1) Gradation: Test in accordance with ASTM C136. Use sieves with square openings for testing grading of aggregates.
  - 2) Alkali-silica reactivity:
    - a) Provide fine and coarse aggregate with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260 , unless the aggregate has been determined to be not deleteriously reactive based on testing in accordance with one of the following:
      - (1) ASTM C1293: Expansion not greater than 0.04 percent at 1 year.
- e. Fine aggregate:
  - 1) Provide fine aggregate that does not contain strong alkali nor organic matter which gives color darker than standard color when tested in accordance with ASTM C40.
  - 2) Provide aggregate having soundness in accordance with ASTM C33 when tested in accordance with ASTM C88.
- f. Coarse aggregate:
  - 1) Soundness when tested in accordance with ASTM C88: Have loss not greater than 10 percent when tested with sodium sulfate.
  - 2) Abrasion Loss: Not exceed 45 percent after 500 revolutions when tested in accordance with ASTM C131.
- g. Fly ash:
  - 1) Sampling and testing: Sample and test fly ash in accordance with ASTM C311.
- h. Portland cement:
  - 1) Determination of alkali content: In accordance with ASTM C114.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Liquid evaporation retardant:
  1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, immediately after the concrete has been screeded, coat the surface of the concrete with a liquid evaporation retardant.
  2. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks.
  3. Conditions which result in rapid evaporation of moisture may include one or more of the following:
    - a. Low humidity.
    - b. Windy conditions.
    - c. High temperature.
- B. Surface sealant system:
  1. Apply as recommended by manufacturer published instructions.



2. Where concrete continues to sweat or leak, apply additional coats of surface sealant until the sweating or leaks stop.
- C. Joints and bonding:
  1. As far as practicable construct concrete work as monolith.
  2. Locations of construction, expansion, and other joints are indicated on the Drawings or as specified in this Section.
  3. Time between placement of adjacent concrete separated by joints:
    - a. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
      - 1) Slabs.
      - 2) Walls.
    - b. Provide not less than 7 days (168 hours) between placement of upper and lower pours for the following:
      - 1) Walls over slabs.
      - 2) Slabs over walls.
      - 3) Slabs keyed into the sides of walls.
  4. Construction joints:
    - a. Where construction joints are not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
    - b. In order to preserve strength and watertightness of structures, make no other joints, except as authorized the Engineer.
    - c. At construction joints, thoroughly clean concrete of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of heavy sandblasting.
    - d. Cleaning of construction joints:
      - 1) Wash construction joints free of sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
      - 2) Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use vacuum cleaner for their removal, after which flush cleaned surfaces with water.
      - 3) Provide cleanout hole at base of each wall and column for inspection and cleaning.
    - e. At horizontal joints: As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03600 - Grouting with a thickness of not less than 1/2 inch nor more than 1 inch.
  5. Take special care to ensure that concrete is well consolidated around and against waterstops and waterstops are secured in proper position.
  6. Contraction, construction, and expansion Joints:
    - a. Constructed where and as indicated on the Drawings.
    - b. Waterstops, expansion joint material, synthetic rubber sealing compound, and other similar materials: As specified in Sections 03150 - Concrete Accessories and 07900 - Joint Sealants.
  7. Repair of concrete: Where it is necessary to repair concrete by bonding mortar or new concrete to concrete which has reached its initial set, first coat surface of set concrete with epoxy bonding agent as specified in Section 03071 - Epoxies.





- D. Conveying and placing concrete:
1. Convey concrete from mixer to place of final deposit by methods that prevent separation or loss of materials.
  2. Use equipment for chuting, pumping, and conveying concrete of such size and design as to ensure practically continuous flow of concrete at delivery end without segregation of materials.
  3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
  4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of day's placement.
- E. Placing concrete:
1. Place no concrete without prior authorization of the Engineer.
  2. Do not place concrete until:
    - a. Reinforcement is secure and properly fastened in its correct position and loose form ties at construction joints have been retightened.
    - b. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
    - c. Forms have been cleaned and oiled as specified.
  3. Do not place concrete in which initial set has occurred, or that has been retempered.
  4. Do not place concrete during rainstorms or high velocity winds.
  5. Protect concrete placed immediately before rain to prevent water from coming in contact with such concrete or winds causing excessive drying.
  6. Keep sufficient protective covering on hand at all times for protection of concrete.
  7. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested and accepted by the Engineer.
  8. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
    - a. Provide this notification in such time in advance of operations, as the Engineer deems necessary to make final inspection of preparations at location of proposed concrete placing.
    - b. Place forms, reinforcement, screeds, anchors, ties, and inserts in place before notification of readiness is given to the Engineer.
    - c. Depositing concrete:
      - 1) Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      - 2) Do not deposit concrete in large quantities in one place and work along forms with vibrator or by other methods.
      - 3) Do not drop concrete freely into place from height greater than 5 feet.
      - 4) Use tremies for placing concrete where drop is over 5 feet.
      - 5) Commence placement of concrete on slopes, starting at bottom of slope.
  9. Place concrete in approximately horizontal layers not to exceed 24 inches in depth and bring up evenly in all parts of forms.
  10. Continue concrete placement without avoidable interruption, in continuous operation, until end of placement is reached.



11. After concrete placement begins, continue concrete placement without significant interruption. Plan and implement precautions to prevent any delay, between layers being placed, from exceeding 20 minutes.
  12. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout not less than 1/2 inch in thickness nor more than 1 inch in thickness over surface before placing additional concrete.
  13. Placement of concrete for slabs, beams, or walkways:
    - a. If cast monolithically with walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
    - b. Allow set time of not less than 1 hour for shrinkage.
- F. Consolidating concrete:
1. Place concrete with aid of acceptable mechanical vibrators.
  2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the work.
  3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
  4. Vibrators:
    - a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    - b. In addition to vibrators in actual use while concrete is being placed, have on hand minimum 1 spare vibrator in serviceable condition.
    - c. Do not place concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.
  5. Take special care to place concrete solidly against forms to leave no voids.
  6. Take every precaution to make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
- G. Footings and slabs on grade:
1. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
  2. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
  3. If subgrade becomes dry prior to concrete placement, sprinkle again, without forming pools of water.
  4. Do not place concrete if subgrade is muddy or soft. Maximum deformation of the subgrade under a fully loaded ready mix truck shall not exceed 1/2 inch.
- H. Loading concrete:
1. Green concrete:
    - a. No heavy loading of green concrete will be permitted.
  2. No backfill shall be placed against concrete walls, connecting slabs, or beams until the concrete has reached the specified strength.
  3. Use construction methods, sequencing, and allow time for concrete to reach adequate strength to prevent overstress of the concrete structure during construction.





I. Curing concrete:

1. General:

- a. Cure concrete by methods specified in this Section.
- b. Keep concrete continuously moist and at a temperature of at least 50 degrees Fahrenheit for minimum of 7 days after placement.
- c. Cure concrete to be painted with water or sheet membrane.
- d. Do not use sprayed membrane curing or sealing compounds on concrete surfaces that are to receive paint or upon which any material is to be bonded.
- e. Water cure or sheet membrane cure concrete slabs that are specified to be sealed by concrete sealer.
- f. Cure other concrete by water curing or sprayed membrane curing compound at the Contractor's option.
- g. Floor slabs may be cured using sheet membrane curing.

2. Water curing:

- a. Keep surfaces of concrete being water cured constantly and visibly moist day and night for period of not less than 7 days.
- b. Each day forms remain in place count as 1 day of water curing.
- c. No further curing credit will be allowed for forms in place after contact has once been broken between concrete surface and forms.
- d. Do not loosen form ties during period when concrete is being cured by leaving forms in place.
- e. Flood top of walls with water at least 3 times per day, and keep concrete surfaces moist at all times during 7 day curing period.

3. Sprayed membrane curing compound:

- a. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
- b. If more than 1 hour elapses after removal of forms, do not use curing compound, but use water curing for full curing period.
- c. If surface requires repairing or painting, water cure such concrete surfaces.
- d. Do not remove curing compound from concrete in less than 7 days.
- e. Curing compound may be removed only upon written request by Contractor and acceptance by Engineer, stating what measures are to be performed to adequately cure concrete.
- f. Take care to apply curing compound to construction joints. Apply to all surfaces along full profile of joints.
- g. After curing period is complete, remove curing compound placed within construction joint profile by heavy sandblasting prior to placing any new concrete.
- h. Contractor's Option: Instead of using curing compound for curing of construction joints, such joints may be water cured.
- i. Apply curing compound by mechanical, power operated sprayer and mechanical agitator that will uniformly mix all pigment and compound.
- j. Apply curing compound in at least 2 coats.
- k. Apply each coat in direction 90 degrees to preceding coat.
- l. Apply curing compound in sufficient quantity so that concrete has uniform appearance and that natural color is effectively and completely concealed at time of spraying.
- m. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.



- n. Thickness and coverage of curing compound: Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
  - o. The Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and also more than is customary in the trade.
  - p. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.
  - q. If the Contractor desires to use curing compound other than specified curing compound, coat sample areas of concrete wall with proposed curing compound and also similar adjacent area with specified compound in specified manner for comparison:
    - 1) If proposed sample is not equal or better, in opinion of the Engineer, in all features, proposed substitution will not be allowed.
  - r. Prior to final acceptance of the work, remove, by sandblasting or other acceptable method, any curing compound on surfaces exposed to view, so that only natural color of finished concrete is visible uniformly over entire surface.
4. Sheet membrane curing:
- a. Install sheet membrane as soon as concrete is finished and can be walked on without damage.
  - b. Seal joints and edges with small sand berm.
  - c. Keep concrete moist under sheet membrane.
- J. Cold weather concreting:
- 1. Preparation before concreting:
    - a. Remove snow, ice, and frost from the surfaces, including reinforcement against which the concrete is to be placed.
    - b. The subgrade shall be free of frost before concrete placing begins.
    - c. Do not place concrete around any embedment that is at a temperature below freezing and is sufficiently massive as to cause the adjacent concrete to freeze.
  - 2. Placement of concrete:
    - a. Placement temperature:
      - 1) The minimum temperature of concrete immediately after placement shall be as specified in Table C.
      - 2) The temperature of concrete as placed shall not exceed the values shown in Table C by more than 20 degrees Fahrenheit.
    - b. Protection temperature:
      - 1) Unless otherwise specified, the minimum temperature of concrete during the protection period shall be as shown Table C.
      - 2) Temperatures specified to be maintained during the protection period shall be those measured at the concrete surface, whether the surface is in contact with formwork, insulation, or air.
      - 3) Measure the temperature with a surface measuring device accurate to 2 degrees Fahrenheit.
      - 4) Measure the temperature of concrete in each placement at regular time intervals as specified in the contract documents.
    - c. Termination of protection:



- 1) The maximum decrease in temperature measured at the surface of the concrete in a 24-hour period shall not exceed the values listed in Table C.
- 2) Do not exceed these limits until the surface temperature of the concrete is within 20 degrees Fahrenheit of the ambient temperature of surrounding temperatures.
- 3) When the surface temperature of the concrete is within 20 degrees Fahrenheit of the ambient temperature, all protection may be removed.

TABLE C CONCRETE TEMPERATURE REQUIREMENTS		
Least dimension of section (inches)	Minimum temperature of concrete as placed and to be maintained during the protection period (degrees Fahrenheit)	Maximum for gradual decrease in surface temperature during any 24 hour period after end of protection period (degrees Fahrenheit)
Less than 12	55	50
12 to less than 36	50	40
36 to 72	45	30
Greater than 72	40	20

3. Curing of concrete:
  - a. Prevent concrete from drying during the required curing period. If water curing is used, terminate use at least 24 hours before any anticipated exposure of the concrete to freezing temperatures.
4. Protection of concrete:
  - a. Combustion heaters: Vent flue gases from combustion heating units to the outside of the enclosures.
  - b. Overheating and drying: Place and direct heaters and ducts to avoid areas of overheating or drying of the concrete surface.
  - c. Maximum air temperature: During the protection period, do not expose the concrete surface to air having a temperature more than 20 degrees Fahrenheit above the values shown in Table C unless higher values are required by an accepted curing method.
  - d. Protection against freezing:
    - 1) Cure and protect concrete against damage from freezing for a minimum of 3 days, unless otherwise specified.
      - a) Maintain the surface temperature of the concrete as specified in Table C.
    - 2) During periods not defined as cold weather, but when freezing temperatures may occur, protect concrete surfaces against freezing for the first 24 hours after placing.

### 3.02 CONCRETE FINISHING

- A. Provide concrete finishes as specified in Section 03366 - Tooled Concrete Finishing as indicated on the Concrete Finish Schedule on the Drawings.



- B. Edges of joints:
1. Provide joints having edges as indicated on the Drawings.
  2. Protect wall and slab surfaces at edges against concrete spatter and thoroughly clean upon completion of each placement.

### 3.03 FIELD QUALITY CONTROL

- A. Testing of concrete:
1. During progress of construction, the Owner will have tests made to determine whether the concrete, as being produced, complies with requirements specified.
  2. Tests will be performed in accordance with ASTM C31, ASTM C39, and ASTM C172.
  3. Contractor shall hire a Certified Independent Laboratory that will make and deliver test cylinders to the laboratory and testing expense will be borne by the Contractor.
  4. Furnish test equipment.
  5. Make provisions for and furnish concrete for test specimens, and provide manual assistance to the Engineer in preparing said specimens.
  6. Assume responsibility for care of and providing of curing conditions for test specimens in accordance with ASTM C31.
  7. Sampling frequency:
    - a. 1 set of test cylinders for each 100 cubic yards of each class of concrete.
    - b. Minimum of 1 set of test cylinders for each class of concrete placed.
    - c. Not less than 1 set of test cylinders for each half-day's placement.
    - d. At least 2 sets of test cylinders for each structure.
- B. Compressive strength tests:
1. Set of 3 cylinder specimens, 6-inch diameter by 12 inch long.
  2. Information: Test 1 cylinder at 7 days.
  3. Acceptance: Test 2 cylinders at 28 days.
- C. Slump tests:
1. Test slump of concrete using slump cone in accordance with ASTM C143.
  2. Do not use concrete that does not meet specification requirements in regards to slump:
    - a. Remove such concrete from project site.
    - b. Test slump at the beginning of each placement, as often as necessary to keep slump within the specified range, and when requested to do so by the Engineer.
- D. Air entrainment tests:
1. Test percent of entrained air in concrete at beginning of each placement, as often as necessary to keep entrained air within specified range, and when requested to do so by the Engineer.
  2. Do not use concrete that does not meet Specification requirements for air entrainment:
    - a. Remove such concrete from project site.
  3. Test air entrainment in concrete in accordance with ASTM C173.
  4. The Engineer may at any time test percent of entrained air in concrete received on project site.



- E. Enforcement of strength requirement:
1. Concrete is expected to reach a compressive strength ( $f'_c$ ) equal to or greater than that the minimum specified in Table A.
  2. Strength level of concrete will be considered acceptable if following conditions are satisfied:
    - a. Averages of all sets of 3 consecutive strength test results is greater or equal to specified compressive strength( $f'_c$ ).
    - b. No individual strength test (average of 2 cylinders) falls below specified compressive strength ( $f'_c$ ) by more than 500 pounds per square inch.
  3. Non-compliant strength tests:
    - a. Mark non-compliant strength test reports to highlight that they contain non-complying results and immediately forward copies of test reports to all parties on the test report distribution list.
    - b. Provide treatment of non-compliant concrete at no additional cost to Owner and with no additional time added to project schedule:
    - c. Initial treatment may consist of additional curing and testing of the affected concrete.
      - 1) Provide additional curing of concrete using means and duration acceptable to the Engineer.
      - 2) Upon completion of the additional curing, provide additional testing designated by the Engineer.
        - a) Obtain and test core samples for compression strength in accordance with ASTM C42, ACI 318, and ACI 350.
        - b) Provide not less than 3 cores for each affected area. Obtain Engineer's acceptance of proposed coring locations before proceeding with that work.
        - c) Submit report of compression strength testing for Engineer's review.
        - d) If required by the Engineer, provide additional cores and obtain petrographic examination in accordance with ASTM C856. Submit report of petrographic analysis for Engineer's review.
      - 3) If additional curing does not bring average of 3 cores taken in affected area to at least the minimum specified compressive strength ( $f'_c$ ), designate such concrete in affected area as defective.

### 3.04 ADJUSTING

- A. Provide repair of defective concrete at no additional cost to Owner and with no additional time added to the project schedule:
- B. Make repairs using approach and means acceptable to the Engineer:
1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
  2. Do not patch, repair, or cover defective work without inspection by the Engineer.
  3. Acceptable means may include, but are not limited to strengthening, repair, or removal and replacement.
- C. Strengthening of defective concrete:
1. By addition of concrete.
  2. By addition of reinforcing.
  3. By addition of both concrete and reinforcing.



D. Repairs:

1. Methods of repair:
  - a. Dry pack method:
    - 1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
    - 2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
  - b. Mortar replacement method:
    - 1) Use for holes too wide to dry pack and too shallow for concrete replacement.
    - 2) Comparatively shallow depressions, large or small, which extend no deeper than nearest surface reinforcement.
  - c. Concrete replacement method:
    - 1) Use when holes extend entirely through concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
2. Preparation of concrete for repair:
  - a. Chip out and key imperfections in the work and make them ready for repair.
  - b. Obtain Engineer's acceptance of surface preparation methods and of prepared surfaces prior to repair.
  - c. Surfaces of set concrete to be repaired: First coat with epoxy bonding agent as specified in Section 03071 - Epoxies.

E. Remove and replace defective concrete.

END OF SECTION



## SECTION 03366

### TOOLED CONCRETE FINISHING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Tooled concrete finishes.

##### 1.02 QUALITY ASSURANCE

- A. Mock-ups:
  - 1. Test panels for concrete finishes:
    - a. Prepare test panels for F4 and F5 finishes and tie-hole repairs for review by Engineer.
    - b. Accepted test panels serve as standard of quality and workmanship for project.
  - 2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
  - 3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
    - a. Accepted test panels serve as standard for repairs during the project.

##### 1.03 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
  - 1. Deliver and store packaged materials in original containers until ready for use.

#### PART 2 PRODUCTS

##### 2.01 MIXES

- A. Mortar mix for F4 finish: Consist of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.
- B. Mortar mix for F5 finish: Consist of 1 part cement to 1-1/2 parts of sand which passes Number 16 screen.

#### PART 3 EXECUTION

##### 3.01 CONCRETE FINISHES

- A. Cement for finishes:
  - 1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.





- B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
1. F1 finish: No special treatment other than repair defective work and fill depressions 1 inch or deeper and tie holes with mortar after removal of curing compound.
  2. F2 finish: No special treatment other than repair defective work, remove fins, fill depressions 1/2 inch or deeper and tie holes with mortar after removal of curing compound.
  3. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
  4. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar.
    - a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
    - b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
    - c. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
    - d. Do not let any material remain on surfaces, except that within pits and depressions.
    - e. Wipe surfaces clean and moist cure.
  5. F5 finish: Receive same finish as specified for F3 finish, and, in addition, receive special stoned finish, in accordance with following requirements:
    - a. Remove forms and perform required repairs, patching, and pointing as specified in this Section.
    - b. Wet surfaces thoroughly with brush and rub with hard wood float dipped in water containing 2 pounds of portland cement per gallon.
    - c. Rub surfaces until form marks and projections have been removed.
    - d. Spread grindings from rubbing operations uniformly over surface with brush in such manner as to fill pits and small voids.
    - e. Moist cure brushed surfaces and allow to harden for 3 days:
      - 1) After curing, obtain final finish by rubbing with carborundum stone of approximately Number 50 grit until entire surfaces have smooth texture and are uniform in color.
      - 2) Continue curing for remainder of specified time.
    - f. If any concrete surface is allowed to become too hard to finish in above specified manner, sandblast and wash related surfaces exposed to view, whether finished or not.
      - 1) While still damp, rub over surface, plastic mortar, as specified for brushed surfaces and handstoned with Number 60 grit carborundum stone, using additional mortar for brushed surfaces until surface is evenly filled without an excess of mortar.
      - 2) Continue stoning until surface is hard.
      - 3) After moist curing for 3 days, make surface smooth in texture and uniform in color by use of Number 50 or Number 60 grit carborundum stone.
      - 4) After stoning, continue curing until 7 day curing period is completed.





- C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:
1. S1 finish: Screeded to grade and leave without special finish.
  2. S2 finish: Smooth steel trowel finish.
  3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.
  4. S4 finish: Steel trowel finish, without local depressions or high points, followed by light hairbroom finish. Do not use stiff bristle brooms or brushes. Perform brooming parallel to slab-drainage. Provide resulting finish that is rough enough to provide nonskid finish. Finish is subject to review and acceptance by the Engineer.
  5. S5 finish: Nonslip abrasive: After concrete has been screeded level and hardened enough to support man standing on a board, sprinkle abrasive from shake screen into surface at uniform rate of 25 pounds for each 100 square feet of surface area, wood float into finish, then trowel abrasive into surface with steel trowel properly exposing abrasive in surface as required to provide nonslip surface.
  6. S6 finish: Roughened finish: After concrete has been screeded to grade, apply a roughened finish by use of a jitterbug roller or similar device.
- D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

### 3.02 CONCRETE FINISH SCHEDULE

- A. Finish concrete surfaces as follows:
1. F4 finish for following vertical surfaces:
    - a. Concrete surfaces specified or indicated to be painted.
    - b. Concrete surfaces, interior or exterior, exposed to view.
  2. Surfaces in open channels, basins, and similar structures:
    - a. F3 finish for vertical surfaces which are normally below water surface.
    - b. F4 finish for vertical surfaces located above normal water surface and exposed to view.
    - c. Remove fins and fill tie holes from concrete surfaces located in closed boxes or channels where there is normally no access or passageway.
  3. S1 finish for following surfaces:
    - a. Projecting footings which are to be covered with dirt.
    - b. Slab surfaces which are to be covered with concrete fill.
  4. S2 finish for following surfaces:
    - a. Tops of corbels.
    - b. Tops of walls and beams not covered above in this Section.
    - c. Tops of slabs not covered above in this Section.
    - d. All other surfaces not specified to be finished otherwise.
  5. S3 finish for following surfaces:
    - a. Building and machine room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.
  6. S4 finish for following surfaces:
    - a. Exterior walkways.
    - b. Tops of exterior walls or beams which are to serve as walkways.
    - c. Tops of exterior walls or beams which are to support gratings.



- d. Top surface of slabs for basins, channels, digesters, and similar structures.
- 7. S6 finish for following surfaces:
  - a. Basin bottoms, or other similar slab surfaces, over which layer of basin bottom grout will be applied.

END OF SECTION



## SECTION 03600

### GROUTING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Cement grout.
  - 2. Cement mortar.
  - 3. Dry-pack mortar.
  - 4. Epoxy grout.
  - 5. Grout.
  - 6. Non-shrink epoxy grout.
  - 7. Non-shrink grout.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
  - 2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
  - 3. C531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
  - 4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes.
  - 5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
  - 6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
  - 7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
  - 8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.
- B. International Concrete Repair Institute (ICRI):
  - 1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

##### 1.03 SUBMITTALS

- A. Cement grout:
  - 1. Mix design.
  - 2. Material submittals.
- B. Cement mortar:
  - 1. Mix design.
  - 2. Material submittals.



- C. Non-shrink epoxy grout:
  - 1. Manufacturer's literature.
- D. Non-shrink grout:
  - 1. Manufacturer's literature.

#### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.
- B. Store materials in cool dry place and in accordance with manufacturer's recommendations.
- C. Handle materials in accordance with the manufacturer's instructions.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURED UNITS**

- A. Non-shrink epoxy grout:
  - 1. Manufacturers: One of the following or equal:
    - a. Five Star Products, Inc., Five Star DP Epoxy Grout.
    - b. BASF Construction Chemicals, Masterflow 648 CP Plus.
    - c. L&M Construction Chemicals, Inc., EPOGROUT.
  - 2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
  - 3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
  - 4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
  - 5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
  - 6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
  - 7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.
- B. Non-shrink grout:
  - 1. Manufacturers: One of the following or equal:
    - a. Five Star Products, Inc., Five Star Grout.
    - b. BASF Construction Chemicals, Masterflow 928.
    - c. L&M Construction Chemicals, Inc., CRYSTEX.
  - 2. In accordance with ASTM C1107.
  - 3. Preportioned and prepackaged cement-based mixture.
  - 4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
  - 5. Require only addition of potable water.
  - 6. Water for pre-soaking, mixing, and curing: Potable water.



7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
  - a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
  - a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
  - b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

## 2.02 MIXES

- A. Cement grout:
  1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
  2. Use same materials for cement grout that are used for concrete.
  3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
  4. For spreading over surfaces of construction or cold joints.
- B. Cement mortar:
  1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
  2. Use same materials for cement mortar that are used for concrete.
  3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
  4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.
- C. Dry-pack mortar:
  1. Proportions by weight: 1 part portland cement to 2 parts concrete sand.
    - a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
    - b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.
- D. Epoxy grout:
  1. Consist of mixture of epoxy or epoxy gel and sand.
    - a. Epoxy: As specified in Section 03071 - Epoxies.
    - b. Epoxy gel: As specified in Section 03071 - Epoxies.
    - c. Sand: Clean, bagged, graded, and kiln-dried silica sand.
  2. Proportioning:
    - a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
    - b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.



- E. Grout:
  - 1. Mix in proportions by weight: 1 part portland cement to 4 parts concrete sand.
    - a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
    - b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.
- F. Non-shrink epoxy grout:
  - 1. Mix in accordance with manufacturer's installation instructions.
- G. Non-shrink grout:
  - 1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

### **3.02 PREPARATION**

- A. Surface preparation for grouting other baseplates:
  - 1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
  - 2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
    - a. Remove loose or broken concrete.
  - 3. Metal surfaces in contact with grout: Grit blast to white metal surface.

### **3.03 INSTALLATION**

- A. Mixing:
  - 1. Cement grout:
    - a. Use mortar mixer with moving paddles.
    - b. Pre-wet mixer and empty out excess water before beginning mixing.
  - 2. Cement mortar:
    - a. Use mortar mixer with moving paddles.
    - b. Pre-wet mixer and empty out excess water before beginning mixing.
  - 3. Dry-patch mortar:
    - a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.
  - 4. Non-shrink epoxy grout:
    - a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
  - 5. Non-shrink grout:
    - a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
    - b. Do not retemper by adding more water after grout stiffens.



B. Placement:

1. Cement grout:
  - a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
  - b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
  - a. Use mortar mixer with moving paddles.
  - b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
  - a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
  - a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
  - b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
  - a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
  - b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:

1. Cement based grouts and mortars:
  - a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
  - b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
  - a. Cure grouts in accordance with manufacturers' recommendations.
    - 1) Do not water cure epoxy grouts.
  - b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:

1. General:
  - a. Use non-shrink grout as specified in this Section.
  - b. Baseplate grouting shall take place from one side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
  - c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
  - d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.



2. Forms and headboxes:
  - a. Build forms using material with adequate strength to withstand placement of grouts.
  - b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
  - c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
  - d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on one side of baseplate.
  - e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

### **3.04 FIELD QUALITY CONTROL**

- A. Non-shrink epoxy grout:
  1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.
- B. Non-shrink grout:
  1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION





## SECTION 03931

### EPOXY INJECTION SYSTEM

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Epoxy injection system.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. C881 - Standard Test Method for Epoxy-Resin-Base Bonding Systems for Concrete.
  - 2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
  - 3. D638 - Standard Test Method for Tensile Properties of Plastics.
  - 4. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
  - 5. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
  - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
- B. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.

##### 1.03 SUBMITTALS

- A. General: Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. Manufacturer's data completely describing epoxy injection system materials, and including test methods and results for strength in tension, flexure, compression and bond; flexural modulus of elasticity; coefficient of thermal expansion; and elongation.
  - 2. Data demonstrating that products are listed under NSF-61 for use in direct contact with potable water.
- C. Quality control submittals:
  - 1. Certificates of Compliance.
  - 2. Manufacturer's Instructions.
- D. Special procedure submittals:
  - 1. Protection plan for surrounding areas and non-cementitious surfaces.

##### 1.04 QUALITY ASSURANCE

- A. Products:
  - 1. Provide materials that are new and use them within shelf life limitations set forth by manufacturer.



- B. Qualifications:
  - 1. Installer:
    - a. Minimum 5 years' experience in concrete repair, with focus on application of similar systems and products to projects of similar size and scope.
- C. Pre-installation meeting:
  - 1. At least 1 week prior to commencing work of this Section, convene a meeting at the project site to review and discuss the following:
    - a. Surface preparation.
    - b. Substrate conditioning and pre-treatment.
    - c. Installation procedures.
    - d. Environmental conditions (including weather forecast) and curing requirements.
    - e. Testing and inspection procedures.
    - f. Protection of surrounding surfaces and equipment.

#### **1.05 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Labels shall include product identification, batch numbers, and shelf life information.
- B. Store materials off the ground and away from moisture and direct sunlight, and at temperatures within manufacturer's recommended range.
- C. Pre-condition materials to manufacturer's recommended temperatures before mixing and using.

#### **1.06 PROJECT CONDITIONS**

- A. Take precautions to protect surfaces and equipment in the work area from damage and staining.

### **PART 2 PRODUCTS**

#### **2.01 MATERIALS**

- A. General:
  - 1. Repair materials shall be free of chlorides or alkalis (except for those attributed to water).
  - 2. To ensure compatibility of materials and methods, a single manufacturer shall produce and provide all products used together in a single area of concrete repair.
  - 3. Listed under NSF-61 for use in direct contact with potable water.
- B. Manufacturers: One of the following or equal:
  - 1. BASF Building Systems, MasterInject 1500 (formerly Concrecive Standard LVI).
  - 2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.



- C. Epoxy:
1. In accordance with ASTM C881, Types I, II and IV, Grade 1, Class C.
  2. Water-insensitive 2-component low viscosity, epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

Table 1 - Epoxy, Physical Properties		
Characteristic	Test Method	Required Results, minimum <sup>(1,2)</sup>
Viscosity (mixed)	--	250 - 375 centipoise
Tensile Strength	ASTM D638	7,500 pounds per square inch
Tensile Elongation at Break	ASTM D638	1 percent
Compressive Strength	ASTM D695	11,000 pounds per square inch
Compressive Modulus	ASTM D695	2.5 x 10 <sup>5</sup> pounds per square inch.
Bond Strength, slant shear, hardened concrete to hardened concrete	ASTM C882	1500 pounds per square inch at 2 days at minimum 73 degrees Fahrenheit. Concrete shall fail before failure of epoxy.
Heat Deflection Temperature	ASTM D648	124 degrees Fahrenheit
Notes:		
1)	Properties for mixes with neat epoxy.	
2)	Results after 7-day cure at temperature between 72 and 78 degrees Fahrenheit, unless otherwise noted.	

## 2.02 EQUIPMENT

- A. Injection pump:
1. Use positive displacement injection pump with interlock to provide in-line mixing and metering system for 2 component epoxy.
  2. Use pressure hoses and injection nozzle designed to properly mix of 2 components of epoxy.
  3. Standby injection unit may be required.

## PART 3 EXECUTION

### 3.01 PREPARATION

- A. Surface preparation:
1. Confirm that surface temperature and moisture conditions are within manufacturer's recommended limits. Condition surfaces to within those limits before commencing epoxy injection.
  2. Sweep or clean area in vicinity of cracks that will be injected with epoxy. Leave area in generally clean condition after epoxy injection is complete.
  3. Clean cracks so they are free from dirt, laitance, and other loose matter.



## 3.02 INSTALLATION

- A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.
- B. Mixing:
  - 1. Mix epoxy in accordance with manufacturer's installation instructions.
  - 2. Do not use solvents to thin epoxy system materials introduced into cracks or joints.
- C. Injection:
  - 1. Apply adequate surface seal to crack to prevent leakage of epoxy.
  - 2. Establish injection points at distance along crack not less than thickness of cracked member.
  - 3. Crack injection sequence:
    - a. Inject epoxy into crack or joint at first port with sufficient pressure to advance epoxy to adjacent port. Start at lowest port along the injection line and work upwards.
    - b. Seal original port and shift injection to next adjacent port where epoxy appears.
    - c. Continue port-to-port injection until crack has been injected for its entire length.
    - d. For small amounts of epoxy, or where excessive pressure developed by injection pump might further damage structure, premixed epoxy and use hand caulking gun to inject epoxy if acceptable to the Engineer.
    - e. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
    - f. After epoxy injection is complete, remove surface seal material, and refinish concrete in area where epoxy was injected to match existing concrete. Leave finished work and work area in a neat, clean condition.

## 3.03 FIELD QUALITY ASSURANCE

- A. Provide Contractor quality control as specified in Section 01450 - Quality Control.
- B. Field inspections and testing:
  - 1. Submit records of inspections and tests to Engineer within 24 hours after completion.
- C. Manufacturer's services.
  - 1. Pre-installation meeting: Provide manufacturer's technical representative to attend pre-installation meeting specified in this Section.

## 3.04 FIELD QUALITY CONTROL

- A. Provide Owner's quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.
- B. Special inspections special tests, and structural observation:
  - 1. Not required.



- C. Field inspections:
  - 1. Preparation.
    - a. Review manufacturer's product data and installation instructions.
  - 2. Required inspections.
    - a. Observe surfaces to be injected for temperature and moisture conditions and for surface preparation.
    - b. Observe conditioning and mixing of epoxy resin components.
    - c. Observe injection procedures for filling cracks.
  - 3. Records of inspections:
    - a. Provide record of each inspection.
    - b. Submit to Engineer upon request.

### **3.05 NON-CONFORMING WORK**

- A. Rework surface finishes that do not match surrounding concrete to the satisfaction of Engineer at no additional cost to Owner.

END OF SECTION





## SECTION 05120

### STRUCTURAL STEEL

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Structural steel shapes and plate.
  - 2. Fasteners and structural hardware:
    - a. All thread rods.
    - b. All thread rods, high-strength.
    - c. Forged steel structural hardware.
    - d. High-strength bolts.
  - 3. Welding.
  - 4. Bolting.

##### 1.02 REFERENCES

- A. American Institute of Steel Construction (AISC):
  - 1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
  - 2. 360 - Specification for Structural Steel Buildings.
- B. American Iron and Steel Institute (AISI):
  - 1. Steel and stainless steel alloys ("types") as indicated.
- C. American Welding Society (AWS):
  - 1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
  - 2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
  - 3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
  - 4. D1.1 - Structural Welding Code - Steel.
  - 5. D1.6 - Structural Welding Code - Stainless Steel.
- D. ASTM International (ASTM):
  - 1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
  - 2. A36 - Standard Specification for Carbon Structural Steel.
  - 3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 6. A489 - Standard Specification for Carbon Steel Lifting Eyes.
  - 7. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
  - 8. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.



9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  10. A992 - Standard Specification for Structural Steel Shapes.
  11. F436 - Standard Specification for Hardened Steel Washers.
  12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
  13. F594 - Standard Specification for Stainless Steel Nuts.
  14. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
  15. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi Yield Strength.
  16. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
  17. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

### 1.03 DEFINITIONS

- A. Snug-tight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

### 1.04 SUBMITTALS

- A. Product data:
1. Welding electrodes for field welds: Electrode manufacturer's data.
- B. Shop drawings:
1. Fabrication and erection drawings.
- C. Quality control submittals:
1. Welding procedure specifications (WPS) in accordance with AWS D1.1 and D1.6.
    - a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
      - 1) State electrode manufacturer and specific electrodes used.
      - 2) Indicate required AWS qualification for joint.
    - b. Submit WPS with shop drawings that indicate those welds.
    - c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1 and D1.6 for welding procedures qualified by testing.
  2. Welder qualifications: For each welding process and position:
    - a. Welder's qualification certificates.
    - b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1 and D1.6.
  3. Steel fabricator's AISC certification.





- D. Test reports:
  - 1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

## **1.05 QUALITY ASSURANCE**

- A. Certification:
  - 1. Steel fabricators shall be certified by the AISC or other certification acceptable to the Engineer and the building official having jurisdiction.
- B. Welding:
  - 1. Perform welding of structural metals in accordance with AWS D1.1 and D1.6 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
  - 2. Make Welding Procedure Specifications available at the locations where welding is performed.
  - 3. Notify Engineer at least 24 hours before starting shop or field welding.
  - 4. Engineer may check materials, equipment, and qualifications of welders.
  - 5. Remove welders performing unsatisfactory Work, or require requalification.
  - 6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
  - 7. Contractor shall bear costs of retests on defective welds.
  - 8. Contractor shall also bear costs in connection with qualifying welders.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.
- B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

### **2.02 FASTENERS AND STRUCTURAL HARDWARE**

- A. General:
  - 1. Materials: Of domestic manufacture.
  - 2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.
- B. All thread rods:
  - 1. Carbon steel:
    - a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.



- b. High strength all thread rods: In accordance with ASTM F1554, Grade 55.
    - c. Nuts: ASTM A194.
    - d. Washers: ASTM F436.
  - 2. Galvanized carbon steel:
    - a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
    - b. High strength galvanized all thread rods: In accordance with ASTM F1554, Grade 55, and galvanized in accordance with ASTM F2329.
    - c. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
    - d. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.
  - 3. Stainless steel:
    - a. Units descaled, pickled, and passivated as specified in "Fabrication" in this Section.
    - b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
    - c. Type 316:
      - 1) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
      - 2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
      - 3) Washers: Type 316 stainless steel.
- C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- D. Forged steel structural hardware - carbon steel:
  - 1. Clevises and turnbuckles: Forged steel in accordance with AISI C-1035. .
  - 2. Eye nuts / Eye bolts: Forged steel in accordance with AISI C-1030.
    - a. Having geometric and strength characteristics (including proof load, breaking strength, tensile strength, bend test, and impact strength) of eyebolts in accordance with ASTM A489, Type 1.
  - 3. Sleeve nuts: Forged steel in accordance with AISI C-1018 Grade 2.
- E. High-strength bolts:
  - 1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Provide uncoated components unless galvanized coating is indicated on the Drawings.
  - 2. Carbon steel - Uncoated:
    - a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1, or ASTM F3125, Grade A490, Type 1 where Grade A490 bolts are indicated on the Drawings.
    - b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
    - c. Washers:
      - 1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
      - 2) Adjacent to long slotted holes: Fabricated from 5/16-inch thick plate conforming to ASTM A36.
    - d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:



- 1) Compressible washer type direct tension indicators ("DTI"): In accordance with ASTM F959, Type 325-1, or ASTM F959, Type 490-1 where Grade A490 bolts are indicated on the Drawings.
  - 2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 or ASTM F3125, Grade F2280 where Grade A490 bolts are indicated on the Drawings.
3. Carbon steel - Galvanized:
- a. Bolt and nut assemblies fabricated, galvanized, tested for rotational capacity, and shipped accordance with the provisions ASTM F3125, Grade A325 and the RCSC Specification.
  - b. Bolts, nuts, and washers: Hot-dip galvanized in accordance with ASTM F2329.
  - c. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1 and galvanized as specified.
  - d. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade DH, galvanized as specified, and lubricated in accordance with ASTM A563, Supplementary Requirement S1 to minimize galling.
  - e. Washers:
    - 1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1 and galvanized as specified. Flat circular washers unless otherwise indicated on the Drawings.
    - 2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel conforming to ASTM A36, and galvanized in accordance with ASTM A123.
  - f. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
    - 1) Compressible washer type direct tension indicators ("DTI"): In accordance with ASTM F959, Type 325-1, with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
    - 2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
- F. Stainless steel bolts (for use in stainless steel structures):
1. General:
    - a. Bolts and nuts shall be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship bolts with properly fitting nuts attached.
    - b. Units descaled, pickled and passivated as specified in "Fabrication."
  2. Type 316:
    - a. Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
    - b. Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
    - c. Washers: Type 316 stainless steel.
  3. Welded studs: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## **2.03 ISOLATING SLEEVES AND WASHERS**

- A. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete.



04

## **GALVANIZED SURFACE REPAIR**

- A. Manufacturers: The following or equal:
1. Jelt, Galvinox.

### **2.05 THREAD COATING**

- A. Manufacturers: One of the following or equal:
1. Bostik, Never-Seez.
  2. Oil Research, Inc., WLR No. 111.

### **2.06 SUPPLEMENTARY PARTS**

- A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

### **2.07 FABRICATION**

- A. Shop assembly:
1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
  2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
  3. Round off sharp and hazardous projections and grind smooth.
  4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
  5. Take responsibility for correct fitting of metalwork.
  6. Welded connections:
    - a. Comply with AWS requirements for the metals to be welded.
    - b. Weld only in accordance with approved Welding Procedure Specifications.
    - c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.
- B. Stainless steel shapes and assemblies:
1. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
    - a. Fabricate shapes using laser-fused, full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as that of members indicated on the Drawings.
    - b. Fabricate shapes from dual grade stainless steel.
    - c. Fabricate beams and channels to ASTM A6 tolerances.
    - d. Manufacturers: The following or equal:
      - 1) Stainless Structural, LLC.
  2. Cleaning and passivation:
    - a. Following shop fabrication of stainless steel members and bolts, clean and passivate fabrications at point of manufacture.
    - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a bright passive finished surface with no etching, pitting, frosting, or discoloration.



- c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
  - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
- d. Pre-clean, chemically de-scale ("pickle"), passivate, and final-clean fabrications in accordance with the requirements of ASTM A380.
  - 1) If degreasing is required before cleaning (pickling) to remove scale or iron oxide, cleaning with citric acid treatments is permissible; however, such treatments shall be followed inorganic cleaners.
  - 2) Pickle and passivate stainless steel using a nitric acid solution in accordance with ASTM A380, Annex A2, Table A2.1, Part II.
  - 3) Pickling by citric acid treatment or sulfuric acid treatment is not considered to satisfy the requirements of this Section.
- e. Inspect after cleaning using methods specified for "gross inspection" in ASTM A380.
- f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the site.

C. Galvanized carbon steel:

- 1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123:
- 2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
- 3. Re-straighten galvanized items that bend or twist during galvanizing.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.02 ERECTION**

- A. General:
  - 1. Fabricate structural and foundry items to true dimensions without warp or twist.
  - 2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
  - 3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
  - 4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
  - 5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
  - 6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
  - 7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.



8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
  9. Round off sharp or hazardous projections and grind smooth.
  10. Paint or coat steel items as specified in Sections 09910 - Painting and 09960 - High-Performance Coatings.
- B. Stainless steel. Take all necessary precautions to avoid iron contamination of stainless steel during delivery, storage, and handling.
1. Segregate stainless steel from iron.
  2. Tools and handling devices.
    - a. Do not use iron tools clamps, chokes, working surfaces, or brushes when fabricating, handling, and erecting stainless steel.
    - b. Do not use tools that have been contaminated by contact with iron.
    - c. Use stainless steel, polymer coated, or wood tools and handling equipment. Do not use tools that have been contaminated by contact with iron or steel.
- C. Welding: General:
1. Make welds full penetration type, unless otherwise indicated on the Drawings.
  2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.
- D. Welding: Carbon steel:
1. General: In accordance with AWS D1.1:
    - a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
    - b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.
- E. Welding - stainless steel:
1. General: In accordance with AWS D1.6.
  2. Field welding of stainless steel will not be permitted.
  3. Passivation of field-welded surfaces:
    - a. Provide cleaning, pickling and passivating as specified under "Fabrications" of this Section. Clean using Derustit Stainless Steel Cleaner, or equal.
- F. Interface with other products:
1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.





- G. Fasteners: General:
  - 1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
  - 2. Anchor bolts and anchor rods: Install as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    - a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snug-tight" condition.
  - 3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
  - 4. All thread rods in drilled holes bonded to masonry with adhesive: Install as specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.
- H. Fasteners: High-strength carbon steel bolts:
  - 1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
  - 2. Provide slip-critical joints at bolted connections.
  - 3. Joints: Slip-critical.
    - a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
    - b. Furnish hardened flat washers in accordance with ASTM F436:
      - 1) On outer plies with slotted holes.
      - 2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
      - 3) Under element, nut, or bolt head, turned in tightening.
    - c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
    - d. Tighten bolts to full pretension.
- I. Fasteners: Stainless steel bolts:
  - 1. Connections shall be snug-tight joints unless otherwise indicated on the Drawings.
  - 2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
  - 3. Rotate nuts using a slow, smooth action without interruptions. Avoid over-tightening.

### **3.03 FIELD QUALITY CONTROL**

- A. Provide quality control as specified in Section 01450 - Quality Control.

### **3.04 FIELD QUALITY ASSURANCE**

- A. Provide quality assurance as specified in Section 01450 - Quality Control.
- B. Special inspections, special tests, and structural observation:
  - 1. Provide as specified in Section 01455 - Special Tests and Inspections.

END OF SECTION







## SECTION 05140

### STRUCTURAL ALUMINUM

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
  - 2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
  - 3. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
- B. American Welding Society (AWS):
  - 1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
  - 2. D1.2 - Structural Welding Code - Aluminum.

##### 1.03 SUBMITTALS

- A. Quality control submittals:
  - 1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
  - 2. Welder's certificates.

##### 1.04 QUALITY ASSURANCE

- A. Qualifications:
  - 1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
  - 2. Notify Engineer 24 hours minimum before starting shop or field welding.
  - 3. Engineer may check materials, equipment, and qualifications of welders.
  - 4. Remove welders performing unsatisfactory work, or require to requalify.
  - 5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
  - 6. Contractor shall bear costs of retests on defective welds.
  - 7. Contractor shall bear costs in connection with qualifying welders.



## ART 2 PRODUCTS

### 2.01 MATERIALS

- A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.
- B. Structural aluminum: ASTM B308, Alloy 6061-T6.
- C. Extruded aluminum: ASTM B221, Alloy 6063-T42.
- D. Isolating sleeves and washers:
  - 1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- E. Miscellaneous materials:
  - 1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
  - 2. Size, form, attachment, and location shall conform to the best of current practice.
  - 3. Conform to applicable ASTM Standards for materials not otherwise specified.

### 2.02 FABRICATION

- A. Aluminum layout:
  - 1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
  - 2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.
- B. Cutting aluminum:
  - 1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
  - 2. Material more than 1/2-inch thick: Saw or rout.
  - 3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
  - 4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
  - 5. Do not flame cut aluminum alloys.
  - 6. Punch or drill rivet or bolt holes to finished size before assembly:
    - a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
    - b. Make holes cylindrical and perpendicular to principal surface.
    - c. Do not permit holes to drift in a manner to distort metal.
- C. Aluminum forming and assembly:
  - 1. Do not heat structural aluminum, except as follows:
    - a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
    - b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.
- D. Before assembly, remove chips lodged between contacting surfaces.
- E. Welding aluminum:
  - 1. Perform welding of aluminum in accordance with AWS D1.2.



2. Weld aluminum in accordance with the following:
  - a. Preparation:
    - 1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
    - 2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
    - 3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
    - 4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
  - b. Filler metal: Aluminum alloys conforming to the requirements of AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
  - c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
  - d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
  - e. Do not use welding process that requires use of a welding flux.
  - f. Neatly make welded closures.
  - g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
  - h. Make welds full penetration welds unless otherwise indicated on the Drawings.

## **2.03 FINISHES**

- A. Coating for dissimilar metals:
  1. Alkali resistant bitumastic:
    - a. Manufacturers: One of the following or equal:
      - 1) Carboline, Bitumastic 50.
      - 2) Tnemec, 46-465.
      - 3) Wasser, MC-Tar 100.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.02 INSTALLATION**

- A. Install structural aluminum products as indicated on the Drawings and specified.
- B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.



- C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
- D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.
- E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.
- F. Interface with other products:
  - 1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
  - 2. Do not paint exposed aluminum surfaces. Remove markings and leave surfaces clean. Coat those parts of aluminum which will be cast into concrete, and those parts of aluminum which will come in contact with masonry, concrete, or wood, with a minimum of 2 coats of specified coating for protection of similar metals.
  - 3. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09960 - High-Performance Coatings.

END OF SECTION



## SECTION 05190

### MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Cast-in anchors and fasteners:
    - a. Anchor bolts.
    - b. Anchor rods.
    - c. Concrete inserts.
    - d. Deformed bar anchors.
    - e. Welded studs.
  - 2. Post-installed steel anchors and fasteners:
    - a. Concrete anchors.
    - b. Sleeve anchors.
    - c. Screw anchors.
    - d. Undercut concrete anchors.
  - 3. Appurtenances for anchoring and fastening:
    - a. Anchor bolt sleeves.
    - b. Isolating sleeves and washers.
    - c. Thread coating for threaded stainless steel fasteners.

##### 1.02 REFERENCES

- A. American Concrete Institute (ACI):
  - 1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.
- B. American National Standards Institute (ANSI):
  - 1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.
- C. American Welding Society (AWS):
  - 1. D1.1 - Structural Welding Code - Steel.
  - 2. D1.6 - Structural Welding Code - Stainless Steel.
- D. ASTM International (ASTM):
  - 1. A29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for.
  - 2. A36 - Standard Specification for Carbon Structural Steel.
  - 3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
  - 4. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
  - 5. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 6. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.



7. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
10. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
11. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
12. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
13. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
14. F436 - Standard Specification for Hardened Steel Washers.
15. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
16. F594 - Standard Specification for Stainless Steel Nuts.
17. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
18. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

- E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

### 1.03 DEFINITIONS

- A. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.
- B. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.
- C. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.
- D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.
- E. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.
- F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
1. Corrosive locations: Describes interior and exterior locations as follows:
    - a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.



- b. Exterior and interior locations at the following treatment structures:
  - 1) Water treatment facilities: All Liquids stream.
  - 2) Water treatment facilities: All Solids stream.
- 2. Wet and moist locations: Describes locations, other than “corrosive locations,” that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
  - a. Exterior portions of buildings and structures.
  - b. Liquid-containing structures:
    - 1) Locations at and below the maximum operating liquid surface elevation.
    - 2) Locations above the maximum operating liquid surface elevation and:
      - a) Below the top of the walls containing the liquid.
      - b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
  - c. Liquid handling equipment:
    - 1) Bases of pumps and other equipment that handles liquids.
  - d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
  - e. Other locations indicated on the Drawings.
- 3. Other locations:
  - a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

#### **1.04 SUBMITTALS**

- A. General:
  - 1. Submit as specified in Section 01330 - Submittal Procedures.
  - 2. Submit information listed for each type of anchor or fastener to be used.
- B. Action submittals:
  - 1. Product data:
    - a. Cast-in anchors:
      - 1) Manufacturer's data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
    - b. Post-installed anchors:
      - 1) For each anchor type, manufacturer's data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
  - 2. Samples:
    - a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
  - 3. Certificates:
    - a. Cast-in anchors:
      - 1) Mill certificates for steel anchors that will be supplied to the site.
    - b. Post-installed anchors:
      - 1) Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.





4. Test reports:
  - a. Post-installed anchors: For each anchor type used for the Work:
    - 1) Current ICC-ES Report (ESR) demonstrating:
      - a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.
5. Manufacturer's instructions:
  - a. Requirements for storage and handling.
  - b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
  - c. Requirements for inspection or observation during installation.
6. Qualification statements:
  - a. Post-installed anchors: Installer qualifications:
    - 1) Submit list of personnel performing installations and include date of manufacturer's training for each.

## **1.05 QUALITY ASSURANCE**

- A. Qualifications:
  1. Post installed anchors shall be in accordance with building code specified in Section 01410 - Regulatory Requirements.
  2. Installers: Post-installed mechanical anchors:
    - a. Conduct a training session with the manufacturer's authorized technical representative for the project on-site:
      - 1) Training shall cover the complete installation process for each type of anchor to be used and shall include, but not be limited to, hole drilling procedures and techniques, hole preparation and cleaning, bolt installation, and bolt proof loading and torquing.
      - 2) Use only trained and qualified personnel for anchor installation.
    - b. Installations shall be performed by trained installers having at least 3 years of experience performing similar installations with similar types of anchors.
- B. Special inspection:
  1. Provide special inspection of post-installed anchors as specified in Section 01455 - Special Tests and Inspections and this Section.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.
- B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.
- C. Protect anchors from weather and moisture until installation.

## **1.07 PROJECT CONDITIONS**

- A. As specified in Section 01610 - Project Design Criteria.
- B. Seismic Design Category (SDC) for structures is indicated on the Drawings.





## **PART 2 PRODUCTS**

### **2.01 MANUFACTURED UNITS**

#### **A. General:**

1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
  - a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
  - b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

#### **B. Materials:**

1. Provide and install anchors of materials as in this Section.

### **2.02 CAST-IN ANCHORS AND FASTENERS**

#### **A. Anchor bolts:**

1. Description:
  - a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
  - b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
    - 1) Rods or bars with angle bend for embedment in concrete (i.e., "L" or "J" shaped anchor bolts) are not permitted in the Work.
2. Materials:
  - a. Ship anchor bolts with properly fitting nuts attached.
  - b. Type 316 stainless steel:
    - 1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
    - 2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
    - 3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
    - 4) Washers: Type 316 stainless steel.
  - c. Galvanized steel:
    - 1) Hot-dip galvanized coating in accordance with ASTM F2329.
    - 2) Bolt: ASTM F1554, Grade 55, heavy hex, coarse thread.
    - 3) Nuts: ASTM A563, Grade A heavy hex, threads to match bolt.
    - 4) Washers: ASTM F436, Type 1.



- B. Anchor rods:
1. Description: Straight steel rod having threads on each end or continuously threaded from end to end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
  2. Materials:
    - a. Stainless steel: Type 316:
      - 1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
      - 2) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
      - 3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of rods.
      - 4) Washers: Type 316 stainless steel.
      - 5) Plates (embedded): ASTM A240.
    - b. Galvanized: steel:
      - 1) Hot-dip galvanized with coating in accordance with ASTM F2329.
      - 2) Rod: ASTM F1554, Grade 55, coarse thread.
      - 3) Nuts: ASTM A563, Grade A, threads to match rod.
      - 4) Washers: ASTM F436, Type 1.
      - 5) Plates (embedded): ASTM A572 Grade 50.
- C. Concrete insert: Ductile embed:
1. Description: 1-piece, integrally hot forged sleeve for embedment in concrete. Provided with flange for nailing to forms and female threaded coupler at the exposed concrete face, and washer-faced hex headed foot to resist pullout from concrete at the embedded end.
  2. Manufacturers: The following or equal:
    - a. Dayton Superior, F-54 Ductile Embed Insert.
  3. Materials:
    - a. Stainless steel: Not available.
    - b. Galvanized steel:
      - 1) Hot-dip galvanized coating in accordance with ASTM A123 or A153 where indicated on the Drawings.
      - 2) Steel: ASTM A29 hot rolled, Grade 1045.
- D. Deformed bar anchors:
1. Description: Steel rod with rebar-like deformations along its length and welding ferrule at one end for attachment to structural steel members (plates or shapes).
  2. Manufacturers: One of the following or equal:
    - a. Nelson Stud Welding Co., D2L Deformed Bar Anchors (D2L-DBA).
    - b. Stud Welding Products, Inc., Deformed Anchor Studs.
  3. Materials:
    - a. Galvanized steel:
      - 1) Hot-dip galvanized coating in accordance with ASTM A153 where indicated on the Drawings.
      - 2) Steel: ASTM A1064 wire deformed for concrete reinforcement.



E. Welded studs:

1. Description: Anchor with forged head for embedment into concrete on one end, and welding ferrule for attachment to steel on the other. Welded to steel members or plates to provide anchorage for steel connections to concrete.
2. Acceptance criteria:
  - a. Welded studs in accordance with AWS D1.1, Type B.
3. Manufacturers: One of the following or equal:
  - a. Nelson Stud Welding Co., H4L Concrete Anchors or S3L Shear Connectors as indicated on the Drawings.
  - b. Stud Welding Products, Headed Concrete Anchors (HCA) or Headed Shear Connectors (HSC) as indicated on the Drawings.
4. Materials:
  - a. Stainless steel: Type 316L:
  - b. Galvanized steel:
    - 1) Hot-dip galvanized after fabrication with coating in accordance with ASTM A123.
    - 2) Steel: Carbon steel in accordance with ASTM A108 with 50,000 pounds per square inch minimum yield strength, and 60,000 pounds per square inch minimum tensile strength.

F. Steel plates or shapes for fabrications including assemblies with welded studs or deformed bar anchors:

1. Stainless steel: Type 316L:
  - a. Plates (embedded): ASTM A240.
2. Galvanized steel:
  - a. Hot dip galvanized in accordance with ASTM A123.
  - b. Steel: ASTM A572 Grade 50.

## **2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE**

- A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete:  
As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
- B. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in masonry:  
As specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

## **2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL**

A. General:

1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01410 - Regulatory Requirements. Reports prepared by other recognized evaluation agencies may be submitted for consideration if acceptable to the Engineer and to the authority having jurisdiction.
  - a. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
    - 1) In regions of concrete where cracking has occurred or may occur.
    - 2) To resist short-term loads due to wind forces.
    - 3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.



2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
  - a. Calculations shall be prepared by and shall bear the signature and seal of a Professional Engineer licensed in the State of Texas .
  - b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.
- B. Concrete anchors:
  1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
    - a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
  2. Concrete anchors for anchorage to concrete:
    - a. Acceptance criteria:
      - 1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
      - 2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
    - b. Manufacturers: One of the following or equal:
      - 1) Hilti, Kwik Bolt TZ Expansion Anchor.
      - 2) DEWALT/Powers, PowerStud.
      - 3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
    - c. Materials. Integrally threaded stud, wedge, washer, and nut:
      - 1) Stainless steel: Type 316.
      - 2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).
- C. Sleeve anchors:
  1. Description: Post-installed, torque-controlled anchor assembly consisting of an externally threaded stud with a spacer sleeve near the surface of the base material, and an expansion sleeve on the lower part of the stud. The expansion sleeve is forced outward by torquing of the center stud to transfer load.
    - a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.



2. Sleeve anchors for anchorage to concrete:
  - a. Acceptance criteria:
    - 1) Sleeve anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    - 2) Sleeve anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
  - b. Manufacturers: One of the following or equal:
    - 1) Hilti, HSL-3 Heavy Duty Expansion (sleeve) Anchor.
    - 2) DEWALT/Powers, Power Bolt+ Heavy Duty Sleeve Anchor.
  - c. Materials:
    - 1) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

D. Screw anchors:

1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creating a helical "key" that is larger than the diameter of the bolt itself along the length of the anchor shaft.
2. Screw anchors for anchorage to concrete:
  - a. Acceptance criteria:
    - 1) Screw anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    - 2) Screw anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
  - b. Manufacturers: Screw anchor: One of the following or equal:
    - 1) Hilti, Hex head, HUS-EZ Screw Anchor:
      - a) With internally threaded head: HUS-EZ I Hanger Anchor.
    - 2) DEWALT/Powers, Screwbolt+ Screw Anchor:
      - a) With internally threaded head: Vertigo+ Rod Hanging System.
    - 3) Simpson Strong-Tie, Titen® HD Screw Anchor:
      - a) With internally threaded head: Titen® HD Rod Hanger.
  - c. Materials:
    - 1) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or equal.

E. Undercut concrete anchors:

1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creation of an undercut "key" at the embedded end of the anchor. The undercut may be achieved with a special drill before anchor installation, or by the anchor itself during installation.



2. Acceptance criteria:
  - a. Acceptance criteria:
    - 1) Undercut concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
    - 2) Undercut anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
  - b. Use pre-setting units. Through-setting units are not allowed unless prior written acceptance for specific locations is obtained from the Engineer.
3. Manufacturers: One of the following or equal:
  - a. Hilti, HDA (carbon steel) or HDA-R (stainless steel) Undercut Anchor.
  - b. Powers Fasteners, Atomic+ Undercut Anchor.
  - c. Simpson Strong-Tie, Torq-Cut Anchor.
  - d. USP Structural Connectors, DUC-L Undercut Anchors.
4. Materials:
  - a. Stainless steel: Corrosive, wet, and moist and locations: Type 316.
  - b. Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

## **2.05 APPURTENANCES FOR ANCHORING AND FASTENING**

- A. Anchor bolt sleeves:
  1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
  2. Plastic sleeves:
    - a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
    - b. Manufacturers: The following or equal:
      - 1) Portland Bolt & Manufacturing Co.
  3. Fabricated steel sleeves: Construct as specified in Section 05500 - Metal Fabrications:
    - a. At galvanized carbon steel anchor bolts, provide galvanized carbon steel sleeves.
    - b. At stainless steel anchor bolts, provide stainless steel sleeves of same Type 316 as bolt, except that sleeves shall be constructed from low carbon stainless steel for welding 316L.
- B. Isolating sleeves and washers:
  1. Manufacturers: One of the following or equal:
    - a. Central Plastics Co.
    - b. Allied Corrosion Industries.
  2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
  3. One sleeve required for each bolt.
  4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
    - a. Proper size to fit bolts.





- b. Two 1/8-inch thick steel washers for each bolt.
- c. G3 Phenolic: 2 insulating washers are required for each bolt:
  - 1) Thickness: 1/8 inch.
  - 2) Base material: Glass.
  - 3) Resin: Phenolic.
  - 4) Water absorption: 2 percent.
  - 5) Hardness (Rockwell): 100.
  - 6) Dielectric strength: 450 volts per mil.
  - 7) Compression strength: 50,000 pounds per square inch.
  - 8) Tensile strength: 20,000 pounds per square inch.
  - 9) Maximum operating temperature: 350 degrees Fahrenheit.
- C. Coating for repair of galvanized surfaces:
  - 1. Manufacturers: The following or equal:
    - a. Jelt, Galvinox.
- D. Thread coating: For use with threaded stainless steel fasteners:
  - 1. Manufacturers: One of the following or equal:
    - a. Bostik, Never-Seez.
    - b. Oil Research, Inc., WLR No. 111.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### **3.02 INSTALLATION: GENERAL**

- A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.
- B. Substitution of anchor types:
  - 1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
  - 2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.
- C. Protect products from damage during installation. Take special care to protect threads and threaded ends.
- D. Accurately locate and position anchors and fasteners:
  - 1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
  - 2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.



- E. Interface with other products:
1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
  2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

### 3.03 INSTALLATION: CAST-IN ANCHORS

- A. General:
1. Accurately locate cast-in and built-in anchors.
    - a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
    - b. Brace or tie off embeddings as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
    - c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
    - d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
  2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
  3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.
- B. Anchor bolts:
1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
  2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Seal top of sleeve to prevent grout from filling sleeve.
- C. Anchor rods:
1. Install as specified for anchor bolts.
- D. Concrete inserts:
1. Provide inserts with minimum clear concrete cover not less than that specified for reinforcing bars.
- E. Deformed bar anchors:
1. Butt weld to steel fabrications with automatic stud welding gun as recommended by manufacturer.
  2. Ensure that butt weld develops the full strength of the anchor.
- F. Welded studs:
1. Butt weld to steel fabrications with automatic stud welding gun as recommended by the manufacturer.
  2. Ensure that butt weld develops full strength of the stud.





### **3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS**

- A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
- B. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in masonry: As specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

### **3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS**

- A. General:
  - 1. Install anchors in accordance with the manufacturer's instructions, ACI 355.2, the anchor's ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.
  - 2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
  - 3. After anchors have been positioned and inserted into concrete or masonry, do not:
    - a. Remove and reuse/reinstall anchors.
    - b. Loosen or remove bolts or studs.
- B. Holes drilled into concrete and masonry:
  - 1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength ( $f'_c$  or  $f'_m$ ).
  - 2. Accurately locate holes:
    - a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
    - b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
  - 3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
    - a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
  - 4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
  - 5. Drill using anchor manufacturer's recommended equipment and procedures:
    - a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
      - 1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
      - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
  - 6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.



7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
- Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
  - Repeat cleaning process as required by the manufacturer's installation instructions.
  - When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.
- C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions.
- Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.
- D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2 1/2 inch	2 5/8 inch	8 inch
1/2 inch	3 1/2 inch	3 1/2 inch	8 inch
5/8 inch	4 1/2 inch	4 1/2 inch	10 inch
3/4 inch	5 inch	5 1/4 inch	12 inch

- E. Flush shell anchors:
- Flush shell anchors are not permitted in the Work.
  - If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.
- F. Sleeve anchors:
- Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Sleeve Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
1/2 inch	2 3/4 inch	Not accepted	8 inch
5/8 inch	3 inch	Not accepted	10 inch
3/4 inch	3 1/4 inch	Not accepted	12 inch

- Install with the sleeve fully engaged in the base material.
- G. Screw anchors:
- Minimum effective embedment lengths unless otherwise indicated on the Drawings:



Screw Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2 1/2 inch	3 1/4 inch	8 inch
1/2 inch	3 1/4 inch	4 1/2 inch	8 inch
5/8 inch	4 inch	5 inch	10 inch
3/4 inch	5 1/2 inch	6 1/4 inch	12 inch

2. Install screw anchors using equipment and methods recommended by the manufacturer. Continue driving into hole until the washer head is flush against the item being fastened.

H. Undercut concrete anchors:

1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Undercut Anchors			
Nominal Diameter (bolt)	Minimum Effective Embedment Length		Minimum Member Thickness <sup>(1)</sup>
	In Concrete	In Grouted Masonry	
3/8 inch	4 inch	Not accepted	8 inch
1/2 inch	5 inch	Not accepted	14 inch
5/8 inch	7 1/2 inch	Not accepted	18 inch
7/8 inch	10 inch	Not accepted	20 inch
Note: (1) Thickness indicated is for pre-set units. If through-set units are accepted, obtain minimum member thickness requirements from the Engineer.			

2. Installations of undercut anchors shall not be allowed where edge distances are less than 12 times the nominal diameter of the anchor stud.
3. Undercut bottom of hole using cutting tools manufactured for this purpose by the manufacturer of the undercut anchors being placed.

### 3.06 FIELD QUALITY CONTROL

- A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450 - Quality Control.
  1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.
- B. Post-installed anchors:
  1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.



2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

### **3.07 FIELD QUALITY ASSURANCE**

- A. Owner or Owner's Representative will provide on-site observation and field quality assurance for the Work of this Section.
  1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.
- B. Field inspections and special inspections:
  1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.
  2. Record of inspections:
    - a. Maintain record of each inspection.
    - b. Submit copies to Engineer upon request.
  3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.
- C. Special inspections: Anchors cast into concrete and built into masonry.
  1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
    - a. Anchor bolts.
    - b. Anchor rods.
    - c. Concrete inserts (all types).
    - d. Deformed bar anchors.
    - e. Welded studs.
  2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
    - a. Anchor:
      - 1) Type and dimensions.
      - 2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
      - 3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
      - 4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
  3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
    - a. Base material (concrete or grouted masonry):
      - 1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.



2) Material encapsulating embedment is dense and well-consolidated.

- D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
1. Provide special inspection during installation of the following anchors:
    - a. Concrete anchors.
    - b. Sleeve anchors.
    - c. Screw anchors.
    - d. Undercut concrete anchors.
  2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
    - a. Provide continuous special inspection for post-installed anchors in “overhead installations” as defined in this Section.
  3. Requirements for periodic special inspection:
    - a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
      - 1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new “initial inspection.”
    - b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor’s rated strength.
    - c. Anchor:
      - 1) Manufacturer, type, and dimensions (diameter and length).
      - 2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
    - d. Hole:
      - 1) Positioning: Spacing and edge distances.
      - 2) Drill bit type and diameter.
      - 3) Diameter, and depth.
      - 4) Hole cleaned in accordance with manufacturer’s required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
      - 5) Anchor’s minimum effective embedment.
      - 6) Anchor tightening/installation torque.
  4. Requirements for continuous special inspection:
    - a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.
- E. Field tests:
1. Owner or Owner’s Representative may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
    - a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
    - b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.



### 3.08 NON-CONFORMING WORK

- A. Remove misaligned or non-performing anchors.
- B. Fill empty anchor holes and repair failed anchor locations using high-strength, non-shrink, non-metallic grout.

### 3.09 SCHEDULES

- A. Provide and install anchor materials as scheduled in the following Table.

Table - Required Anchoring Materials by Location			
Location/Exposure		Materials	Notes
1.	<b>Anchors into concrete and grouted masonry for attachment of carbon steel, including structural steel and other steel fabrications:</b>		
a)	Interior dry areas	Carbon steel - galvanized	
b)	Locations with galvanized steel structures or fabrications	Stainless steel - Type 316	1
c)	Exterior and interior wet and moist locations	Stainless steel - Type 316	1
d)	Corrosive locations	Stainless steel - Type 316	1
2.	<b>Anchors into concrete and grouted masonry for attachment of aluminum, stainless steel, or fiber-reinforced plastic (FRP) shapes and fabrications:</b>		
a)	Interior dry areas	Stainless steel - Type 316	1
b)	Exterior and interior wet and moist locations	Stainless steel - Type 316	1
c)	Corrosive locations	Stainless steel - Type 316	1
3.	<b>Anchors for attaching equipment and its appurtenances:</b>		
a)	All locations	Stainless steel - Type 316 (unless Type 304 is specifically indicated in the specifications for the equipment.)	1
<u>Note:</u> (1) Where anchors are in contact with a metal that differs from that of the anchor, provide isolation sleeves and washers.			

END OF SECTION



## SECTION 05216

### OPEN WEB STEEL JOIST FRAMING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Open web steel joists, joist girders, and accessories.
  - 2. Welding and bolts for connections at joists and joist girders.

##### 1.02 REFERENCES

- A. American Welding Society (AWS):
  - 1. A2.4 - Standard Symbols for Welding, Brazing, and Non-Destructive Examination.
  - 2. B2.1 - Specification for Welding Procedure and Performance Qualification.
  - 3. D1.1 - Structural Welding Code - Steel.
- B. ASTM International (ASTM):
  - 1. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  - 2. F436 - Standard Specification for Hardened Steel Washers.
  - 3. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- C. Occupational Safety and Health Administration (OSHA):
  - 1. Code of Federal Regulations, Title 29 – Labor, Chapter XVII.
    - a. Part 1926.757 - Steel Erection; Open Web Steel Joists.
- D. Society for Protective Coatings (SSPC):
  - 1. Paint 15 - Steel Joist Shop Primer/Metal Building Primer.
  - 2. SP-15 - Commercial Grade Power tool Cleaning.
- E. Steel Joist Institute (SJI):
  - 1. Code of Standard Practice:
    - a. COSP - Code of Standard Practice for Steel Joists and Joist Girders.
  - 2. Standard Specifications:
    - a. K Series - Standard Specifications for Open Web Steel Joists.
    - b. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
    - c. JG Series - Standard Specification for Joist Girders.
  - 3. Standard Load Tables:
    - a. Standard Specification Load Tables and Weight Tables for Steel Joists and Joists Girders.
  - 4. Technical Digests:
    - a. TD 8 - Welding of Open-Web Steel Joists and Joist Girders.
    - b. TD 9 - Handling and Erection of Steel Joists and Joist Girders.





03

## DEFINITIONS

- A. Steel joists: As referred to in this Section, includes joists, K series joist substitutes, joist girders, and joist headers.
- B. SJI Standard Specifications: Refers to one or more of the following documents corresponding to the joist type indicated on the Drawings:
  - 1. K Series - Standard Specifications for Open Web Steel Joists.
  - 2. LH/DLH Series - Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.
  - 3. JG Series - Standard Specification for Joist Girders.
- C. SJI Standard Load Tables: Refers to one of the following documents corresponding to the joist type indicated on the Drawings:
  - 1. Standard Load Tables, Open Web Steel Joists, K-Series (LRFD & ASD).
  - 2. Standard Load Tables, Longspan Steel Joists, LH-Series (LRFD and ASD).
  - 3. Standard Load Tables, Deep Longspan Steel Joists, DLH Series (LRFD and ASD).

## 1.04 SUBMITTALS

- A. General: Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. Manufacturer's specifications and installation instructions for each type of joist and accessories.
  - 2. Coatings:
    - a. Shop coating. Manufacturer's product data sheets indicating type and characteristics of applied coatings, and recommendations for preparation and materials for finished coatings.
- C. Shop drawings:
  - 1. General:
    - a. Provide fabrication drawings/schedules, and erection/layout drawings for all joists and related miscellaneous metal work.
    - b. Clearly indicate portion of the Work covered by each submittal, and location of each member in the work.
    - c. Mark number or tags on joists and fabrications shall be the same mark numbers indicated on fabrication schedules and erection drawings.
    - d. Indicate shop and field welds using symbols in accordance with AWS A2.4. Indicate net weld lengths.
  - 2. Fabrication drawings/schedules:
    - a. Detail each piece or assembly to be incorporated into the work.
    - b. For each joist type and size, and for each accessory, indicate:
      - 1) SJI standard designations including depth and chord size.
      - 2) Identification mark number.
      - 3) Loading criteria and camber.
      - 4) Configuration and details including joist elevation view; bearing seats; end conditions; chord extensions; and details of internal joints, welds, and splices (if any).
      - 5) Dimensions, both overall and internal.
      - 6) Methods of connecting, anchoring, fastening, bracing, bridging, and attaching.





- 7) Coatings and surface preparation.
3. Erection/layout drawings:
  - a. Indicate placement of each piece shown in the fabrication drawings/schedules or listed in the bill of materials.
  - b. Show layout of joists with mark numbers; methods of framing at openings; locations, types, and connection details for bridging; details of connections between joists and supporting joist girders, joist headers, framing, or structures; and accessories.
  - c. Indicate erection sequence and requirements for temporary bracing.
  - d. Show requirements for field welding and bolting.
  - e. Show profiles and deflection criteria under live and total loads for joist configurations not specifically listed in SJI Standard Load Tables.
  - f. List loads used in the design of steel joists.
    - 1) Show loads and position of loads from all mechanical and electrical equipment supported by the joists and framing.
- D. Calculations:
  1. Submit calculations for each joist type and span, documenting adequacy to resist uniform and concentrated loads indicated on the Drawings; locations, sizes and types of bridging for resisting downward and uplift loads; and adequacy of connections of joists and bridging.
  2. Provide calculation cover letter sealed and signed by the joist manufacturer's qualified registered design professional licensed in the state where the Project is located.
- E. Certificates/certifications:
  1. SJI membership. Submit evidence of manufacturer's current membership in SJI and of manufacturer's qualifications to produce members of the types specified and required for the Work.
  2. SJI compliance. At the completion of manufacturer, for each joist type and load case provided, submit manufacturer's certificate of compliance stating that design and fabrication of members was performed in accordance with SJI Standard Specifications and the approved shop drawings. Include manufacturer's statements that:
    - a. Welders performing shop welding for joists hold current qualification for the types of welding and welding positions required for the Work.
    - b. Manufacturer has completed in-plant before shipment to verify compliance of materials and workmanship with the requirements of SJI Standard Specifications for the products produced.
  3. Quality control program: Submit evidence of active participation in a nationally recognized program for quality control of steel fabrication.
  4. Field welding. Submit welder qualification certificates in accordance with AWS D1.1 for the types of welding and welding positions required for the Work.
- F. Test and inspection reports:
  1. Mill test reports: Submit manufacturer's certificates, indicating ASTM standards, structural strength, and material properties for steel used in the joists and bridging.



2. Inspections:
  - a. Source quality control.
    - 1) Submit reports of manufacturer's in-plant inspections for compliance with SJI Standard Specifications.
  - b. Field quality control:
    - 1) Report of erection inspection.
    - 2) Report of welding inspection.

## 1.05 SYSTEM DESCRIPTION

- A. Pre-engineered, pre-fabricated open-web steel joists, joist girders, and accessories designed and fabricated to the requirements of the Steel Joist Institute and details as specified in this Section and indicated on the Drawings.
- B. Design requirements:
  1. Design joists and bridging in accordance with current SJI Specifications and load tables to support loads indicated based on the depth, spacing, and deflections, indicated.
    - a. Maximum deflection under live load:
      - 1) Roof joists: Span divided by 240 .
    - b. Minimum design loads as indicated on the Drawings:
      - 1) Dead load.
      - 2) Live load.
      - 3) Snow load.
      - 4) Wind load (net uplift).
      - 5) Axial tension and compression forces applied to the truss at end connections.
    - c. Camber: Provide standard camber based on SJI Standard Specifications unless otherwise indicated on the Drawings.
      - 1) In no case shall joists be manufactured with negative (downward) camber.
  2. Bridging: Provide horizontal and diagonal bridging as required by the SJI Standard Specifications, as indicated on the Drawings, and as required to maintain stability under gravity, uplift, erection, and construction loadings.
  3. End anchorage: Provide end anchorage details to secure and/or stabilize joists at supports, and to transfer any loads indicated on the Drawings.
  4. Header units: Provide header units to support joists at openings in floor or roof framing not framed with structural steel shapes.
  5. Accessories:
    - a. Provide miscellaneous items including splice plates, reinforcing angles, and bolts required to complete the installation.
    - b. Provide supplemental steel framing to support steel deck where normal deck bearing is precluded by other framing members and minor openings.

## 1.06 QUALITY ASSURANCE

- A. Design and fabricate joists in compliance with the following and as specified in this Section:
  1. SJI Standard Specifications.
  2. SJI Standard Load Tables.
  3. SJI Code of Standard Practice.



- B. Qualifications:
  - 1. Manufacturers:
    - a. Holding current membership in the Steel Joist Institute and a recognized fabricator of structural steel joists conforming to the SJI Standard Specifications, the SJI Standard Load Tables, and the SJI Code of Practice.
  - 2. Installer/Erector:
    - a. Field Welding: Qualified procedures and welders in accordance with AWS D1.1. Provide welders qualified within the last 12 months preceding the date of joist erection.
- C. Regulatory requirements:
  - 1. In accordance with OSHA requirements for steel erection, including specific requirements for joists and framing.
- D. Inspection:
  - 1. Inspect joists in accordance with SJI Standard Specifications.
  - 2. Inspect fabrication as specified in Part 2, Source Quality Control.
  - 3. Provide inspections for Field Quality Control and Field Quality Assurance as specified in Part 3, Execution.
- E. Pre-installation conference: Steel joists and deck.
  - 1. Coordinate with the requirements of Section 05310 - Steel Deck.
  - 2. Schedule and conduct pre-installation conference at least 2 weeks prior to installation of joists.
    - a. Provide additional conferences if necessary to discuss or coordinate specific conditions of installation.
  - 3. Required attendees:
    - a. Contractor.
    - b. Steel joist manufacturer's technical representative.
    - c. Steel joist installer's job superintendent.
    - d. Subcontractor(s) providing and installing coatings under Division 9.
  - 4. Agenda:
    - a. Joist submittals.
    - b. Deck placing and fastening procedures.
    - c. Manufacturer's recommended inspections and inspection procedures.
    - d. Requirements and coordination for quality control inspections and quality assurance (including special inspections).
    - e. Other Specification requirements requiring coordination between parties to the work.
  - 5. Prepare and submit minutes of the pre-installation conference as specified in Section 01312 - Project Meetings.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Transport, deliver, store, and handle steel joists as recommended in SJI specifications, and as required to avoid stresses and to prevent damage to materials and coatings.
- B. Observe delivered materials for damage before and after unloading, and note any permanent bends, deformations, broken welds, or other damage on the receiving documents.



- C. Store joists off the ground, protected from weather and corrosion, and under watertight covering sloped to drain.
  - 1. Support by means that will protect members from distortion and damage.
  - 2. Store joists with top chord down and with plane of joist vertical.

## **1.08 WARRANTY**

- A. As specified in Section 01783 - Warranties and Bonds.
- B. Special warranty:
  - 1. Duration: 5 years warranty on joists.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Steel joists:
  - 1. Provide joist type, chord configuration, depth, and bearing as indicated on the Drawings.
  - 2. Comply with SJI Standard Specifications for joist series indicated and for joist girders.
  - 3. Details: Provide the following.
    - a. Chord members: Rolled double angle sections only. Rod or bar members are not permitted.
- B. Bridging:
  - 1. In accordance with SJI Standard Specifications for type of joist, chord size, spacings, spans and uplift loads indicated on the Drawings.
  - 2. Anchored to walls, girders, and roof deck as indicated.
- C. Coatings:
  - 1. Shop paint. In accordance with SSPC Paint 15.
- D. Fasteners:
  - 1. Anchor bolts and anchor rods to concrete and masonry: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
  - 2. Bolts: pre-tensioned bolted connections.
    - a. Provide high-strength bolt assembly with hardened flat washers and nuts. Provide uncoated components unless galvanized coating is indicated on the Drawings.
    - b. Uncoated:
      - 1) Bolts: Plain, heavy hex structural bolts conforming to ASTM F3125, Grade A325, Type 1.
      - 2) Nuts: Heavy hex nuts conforming to ASTM A563, Grade C.
      - 3) Washers: Circular flat washers conforming to ASTM F436.
- E. Accessories:
  - 1. Bearing plates: As specified in Section 05120 - Structural Steel and or 05500 - Metal Fabrications.



## **2.02 FABRICATION**

- A. Open web steel joists:
  - 1. Fabricate steel joist in accordance with SJI Standard Specifications to details indicated on the Drawings.
- B. Cross bridging: Provide horizontal or diagonal type bridging for joists.
- C. End anchorage: Provide end anchorage, including bearing plates, to secure joists to adjacent construction as indicated on the Drawings.
- D. Coatings:
  - 1. Shop primer:
    - a. Clean and prime joists and accessories in accordance with SSPC Paint 15.

## **2.03 SOURCE QUALITY CONTROL**

- A. Tests and inspections:
  - 1. Provide joist manufacturer's inspection as required by SJI Standard Specifications. Submit inspection results.
  - 2. Special Inspection - Fabrication. Requirements of the building code specified in Section 01450 - Regulatory Requirements for special inspection of fabricated structural items shall be considered to be satisfied when the manufacturer is registered and approved to perform steel fabrication work in accordance with a quality control program that is certified by the Steel Joist Institute (SJI), the American Institute of Steel Construction (AISC), the City of Los Angeles Department of Building and Safety (COLA), or similar program acceptable to building official and the Engineer.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. Furnish and erect steel joists accordance with the requirements of SJI's Code of Standard Practice for Steel Joists and Joist Girders.

### **3.02 PREPARATION**

- A. Field verify dimensions and elevations of structural elements supporting the joists and joist girders.
  - 1. Establish lines and elevations within tolerances before beginning erection.
  - 2. Make bearing surfaces true and uniform.
  - 3. Do not begin placement of steel joists until supporting work is in place and secured.
- B. Clean bearing surfaces of joists and supporting members before erection and as required during erection to maintain solid contact between members.
- C. Do not permit erection of steel deck until joists are connected and bridging is in place.



## INSTALLATION

### A. Erection:

1. Place and secure steel joists in accordance with SJI Standard Specifications, approved erection drawings, and these Specifications.
2. Allow for loads from erection procedures, but do not load joists until all fastening is complete.
3. Provide sufficient temporary bracing to maintain joists and supporting framing safe, plumb, and in true alignment until completion of erection and installation of permanent bridging and bracing.

### B. Installation of joists and bridging:

1. Do not start placement of steel joists until supporting work is in place, adjusted to specified tolerances, and secured.
2. Do not field modify, alter, or repair joists unless specific written instructions have been received from the joist manufacturer and submitted to the Engineer. Such instructions shall bear the seal and signature of the joist manufacturer's registered design professional licensed in the state where the joists are installed.
3. Place joists on supporting surfaces, adjust, and accurately align to required elevation, location and spacing before permanently fastening.
  - a. Set joists plumb and level (with indicated allowances for camber).
  - b. Set "tag end" of joists at location shown on the erection plans.
  - c. Ensure that "square-end" joists are erected with the right side at the top.
  - d. Adjust bearing shoe elevations to provide full bearing after joists and supporting members have been plumbed and positioned, but before final tightening of connections and before any loads are imposed.
  - e. Solidly pack areas under bearing plates using materials and procedures indicated on the Drawings.
4. Install bridging in accordance with OSHA 29CFR-1926.757d and SJI Standard Specifications to provide lateral stability for the joists before slacking of hoisting lines. Quantity of bolted diagonal erection bridging shall be in accordance with SJI Standard Specifications.
5. Install bridging simultaneously with joist erection and before construction loads are applied. Anchor ends of bridging lines at top and bottom chords where terminating at walls or beams. Quantity, size, and sequence for installing bridging shall be in accordance with SJI Standard Specifications.
6. Erection stability and handling shall be in accordance with SJI Standard Specifications.

### C. Fastening joists:

1. Each joist must be attached at a minimum of one end immediately upon placement in the final erection position and before additional joists are placed.
2. When field welding joists, weld to supporting steel framework in accordance with SJI Standard Specifications and as indicated on the Drawings.
  - a. Coordinate welding sequence and procedure with placing of joists.
  - b. In accordance with AWS D1.1.
  - c. Length of field welds applied to the top and bottom chords of joists shall not exceed 1/2 of the width of the steel member.
3. When bolting joists, bolt to supporting steel framework in accordance with SJI Standard Specifications.



- D. Coating:
1. Deliver joists coated or uncoated as indicated on the Drawings and specified.
  2. Where members are painted or coated in place, do not begin preparation or coating until all units are in place; properly, completely, and permanently fastened, and accepted by the Engineer.
  3. Prepare, prime, and finish as specified in Section 09960 - High-Performance Coatings.
  4. Perform surface preparation and coating application under environmentally controlled field conditions, or in an off-site paint shop.

### **3.04 TOLERANCES**

- A. As indicated in SJI Standard Specifications, unless otherwise noted.
- B. Deviation from straight line between opposite ends of any installed joist: Maximum 3/8 inch in 10 feet.

### **3.05 REPAIR**

- A. Do not install damaged joists or accessories. Remove such materials from the site and replace with sound materials at no additional cost to the Owner.
- B. Repair rust spots and coatings damaged by handling, welding, or other erection and fastening processes.
- C. After erection, touch-up rust spots, connections, field welds, and abraded areas of members using specified coatings. Clean and prepare damaged areas. Apply coating at the same thickness as that applied before erection. Feather edges of repairs to provide a uniform appearance after repair.
1. Clean and prepare surfaces using SSPC-SP 15 procedures.
  2. Apply coating of same product and color as member. Apply primer and finish coat(s).

### **3.06 FIELD QUALITY CONTROL**

- A. Provide field quality control over the Work of this Section as required by Section 01450 - Regulatory Requirements.
- B. Field tests and inspections:
1. High-strength bolting:
    - a. Confirm use of specified bolts and nuts.
    - b. Pre-tensioned connections:
      - 1) Confirm that all plies of the connected elements have been brought into firm contact by the tightened connection.
      - 2) Confirm bolts pretension using turn-of-the nut method, twist-off type tension controlled nut, or direct-tension indicator washer. Do not use calibrated wrench.
  2. Welding - Field welds.
    - a. Perform observations and testing in the presence of the Engineer.
    - b. Visual observation:
      - 1) Visually examine all welds in accordance with AWS D1.1.





- 2) Quality of welds and standards for acceptance shall be in accordance with AWS D1.1, "Visual Inspection Acceptance Criteria" Table.
- c. Test results:
  - 1) Submit records of testing to Engineer within 24 hours after testing.
3. After erection, observe installation for conformance with this specification.

### **3.07 FIELD QUALITY ASSURANCE**

- A. Provide field quality assurance over the Work of this Section as required by Section 01450 - Regulatory Requirements.
- B. Special inspections, special tests and structural observation:
  1. Provide as required by Section 01455 - Special Tests and Inspections.
- C. Field inspections:
  1. Required inspections:
    - a. Observe construction for conformance to the Contract Documents and the accepted Shop Drawings.
      - 1) Confirm that joist and accessory locations and tags (marks) match those indicated on the erection drawings.
      - 2) Confirm that joists are installed in vertical alignment and without lateral sweep.
      - 3) Confirm that joist spacing conforms to erection drawings.
      - 4) Confirm that bridging lines, spacing, and connections/anchoring conform to erection drawings.
    - b. Visually inspect field bolting, including bolt tightness.
    - c. Visually inspect field welding using AWS certified welding inspectors in accordance with AWS D1.1.
      - 1) In accordance with AWS D1.1.
      - 2) Mark welds observed.
  2. Records of inspections:
    - a. Provide record of each inspection.
    - b. Submit copies to Engineer upon request.
- D. Field testing.

### **3.08 NON-CONFORMING WORK**

- A. Remove and replace damaged and non-conforming work to the satisfaction of the Engineer.

END OF SECTION





ELEMENTS INSPECTED	REF <sup>(1)</sup>	CONFORMS?		
		Yes	No	Comments <sup>(2)</sup>
<b>Member Installation:</b>				
Joist and accessory locations, tags, and tagged end locations conform to erection drawings.	1			
Joist spacing conforms to erection drawings.	1			
Joists and accessories are installed in horizontal and vertical alignment and without lateral sweep.	1			
Joist bearing length on supporting members conforms to erection drawings and details.	1a			
Joist and accessory installations conform to specified tolerances.				
<b>Bridging:</b>				
Bridging locations, types (horizontal or diagonal), and member sizes conform to erection drawings.	1b			
Bridging connections to joists conforms to erection drawings.	1b			
Bridging connections to and terminations at ends/walls conforms to erection drawings.	1b			
<b>Field Welding:</b>				
Welds at locations indicated on erection drawings.				
Weld size and length as indicated on erection drawings.	1a			
Quality of welds complies with AWS D1.1 - "Visual Inspection Acceptance Criteria" Table	1a			
<b>(Continued, next page)</b>				
<b>Field Bolting:</b>				
Bolts at locations indicated on erection drawings.	1a			
Bolts, nuts and washers of sizes and materials specified.	1a			
Bolts tightened as specified. All plies of connection have been brought into firm contact.	1a			
<b>Other:</b>				



		<b>CONFORMS?</b>	

**Notes:**

(1)     Reference: 2015 IBC Table 1705.2.3.

(2)     Comments: Insert comment number from page 2 this form.

**Comments:**

**Inspector:**

Name (printed): \_\_\_\_\_

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Company (printed): \_\_\_\_\_



## **SECTION 05310**

### **STEEL DECKING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Steel deck for floors and roofs, and associated accessories.

##### **1.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- B. American Welding Society (AWS):
  - 1. D1.3 - Structural Welding Code - Sheet Steel.

##### **1.03 SUBMITTALS**

- A. Product data.
- B. Shop drawings.

##### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Storage and protection:
  - 1. Store steel deck at the site stacked on platforms or pallets and covered with tarpaulins or other suitable weathertight covering.
  - 2. Do not use steel deck for storage or working platform.
  - 3. Remove damaged, unlabeled, untagged, rusty, and deteriorated steel deck material from the job site.

#### **PART 2 PRODUCTS**

##### **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. ASC Profiles (Formerly IMSA Building Products and BHP).
  - 2. Verco Manufacturing Co.

##### **2.02 MATERIALS**

- A. Sheet steel: ASTM A653, G 90 minimum coating designation.



## **2.03 FABRICATION**

- A. Steel deck shall be formed:
  - 1. So every sheet is identical and will register perfectly with adjacent sheets.
  - 2. In accordance with building code as specified in Section 01410- Regulatory Requirements.
- B. Decking used with concrete fill shall be deformed to develop composite action between the deck and the concrete.
- C. Furnish minimum gauge, deck thickness, section modulus, moment of inertia, and allowable diaphragm shear per foot of deck width that is not less than for type deck sections indicated on the Drawings.
- D. Treat exposed roof deck with phosphate.
- E. Furnish roof deck ready to receive field painting without further pretreatment. Paint exposed roof deck in accordance with Contract Documents.
- F. Accessories:
  - 1. Furnish all accessories indicated on the Drawings or needed to completed work.
  - 2. Minimum required gauges:
    - a. Sump pans: 14 gauge.
    - b. All other accessories: 20 gauge unless otherwise indicated on the Drawings.
- G. Welding and electrodes: In accordance with AWS D1.3.
- H. Furnish roof decking in lengths to minimize number of splices.
- I. Furnish steel deck complete, including cutting, shaping, fitting, drilling, welding, ridge plates, valley plates, reinforcing plates for openings, and miscellaneous pieces necessary for proper installation.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

### **3.02 INSTALLATION**

- A. Decking shall span over at least 3 spans wherever possible.
- B. Do not damage or overload roof deck during installation.
- C. Do not use steel deck for storage or as a working platform until sheets have been welded in position.



- D. Do not exceed maximum uniformly distributed load of 20 pounds per square foot.
- E. Install decking in straight and continuous rows as far as practicable, with ribs at right angles to supporting members.
- F. For each end of deck section, provide 3 inches minimum bearing on supports. For sections that abut each other, each piece shall bear a minimum of 3 inches on the support. This requires a 6 inch minimum flange width. For cases where the minimum bearing cannot be obtained, notify the Engineer.
- G. Electric arc weld deck sections to bearing plates, supports at butt joints, at intermediate supports, side supports, and at end supports as indicated on the Drawings. Do not burn through the deck. Remove all slag.
- H. Fasten the longitudinal joints between deck sections together by the method indicated on the Drawings.
- I. Neatly cut and fit openings in roof deck, and reinforce with structural steel members as indicated on the Drawings.
- J. Paint welds as specified.
- K. Install roof deck free of dents and bent members.
- L. Reinforce all holes and openings in steel deck as indicated on the Drawings.
- M. Piping, conduit, equipment, and other services: Do not hang from decking.
- N. Install all accessories required to complete work.

### **3.03 REPAIR OF GALVANIZING AND COATING**

- A. Touch-up damage to galvanized surfaces, including cut edges and holes, with zinc rich primer.
- B. Repair damage to factory-applied coating system in accordance with the manufacturer's printed recommendations.

### **3.04 CLEANUP**

- A. After erection, remove weld spatter, grease, and oil from decking.

END OF SECTION





## SECTION 05500

### METAL FABRICATIONS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Aluminum grating stair tread.
  - 2. Aluminum stair nosing.
  - 3. Cast iron stop plank grooves.
  - 4. Concrete inserts.
  - 5. Handrails and guardrails.
  - 6. Ladders.
  - 7. Manhole frames and covers.
  - 8. Manhole steps
  - 9. Metal gratings.
  - 10. Metal tread plate.
  - 11. Preformed channel pipe supports.
  - 12. Stairs.
  - 13. Miscellaneous metals.
  - 14. Associated accessories to the above items.

##### 1.02 REFERENCES

- A. Aluminum Association (AA):
  - 1. DAF-45: Designations from Start to Finish.
    - a. M12-C22-A41.
- B. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. Standard Specifications for Highway Bridges.
- C. ASTM International (ASTM):
  - 1. A36 - Standard Specification for Carbon Structural Steel.
  - 2. A48 - Standard Specification for Gray Iron Castings.
  - 3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
  - 4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
  - 6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
  - 7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
  - 8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  - 9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
  - 10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.



11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
  12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
  13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  14. A992 - Standard Specification for Structural Steel Shapes.
  15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
  16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
  17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
  18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
  19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
  20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.
- D. American Welding Society (AWS):
1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
- E. National Association of Architectural Metal Manufacturers (NAAMM):
1. Metal Finishes Manual.
- F. Occupational Safety and Health Administration (OSHA).

### **1.03 DEFINITIONS**

- A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

### **1.04 SUBMITTALS**

- A. Product Data:
1. Aluminum grating stair tread.
  2. Aluminum stair nosing.
  3. Cast iron stop plank grooves.
  4. Handrails and guardrails.
  5. Manhole frames and covers.
  6. Manhole steps.
  7. Metal grating.
- B. Shop drawings:
1. Handrails and guardrails:
    - a. Including details on connection attachments, gates, kick plates, ladders, and angles.





- b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
    - c. Include erection drawings, elevations, and details where applicable.
    - d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
  - 2. Ladders.
  - 3. Metal grating.
  - 4. Metal tread plate.
  - 5. Stairs.
  - 6. Miscellaneous metals.
- C. Samples:
  - 1. Guardrails with specified finishes.
- D. Quality control submittals:
  - 1. Design data.
  - 2. Test reports:
    - a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
    - b. Gratings:
      - 1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
      - 2) Reports of tests performed.
    - c. Planks:
      - 1) Plank manufacturers' calculations showing that planks will meet specified load-bearing and deflection requirements for each size plank for each span.
      - 2) Reports of tests performed.

## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
<b>Cast Iron</b>		
Cast Iron	A48	Class 40B
<b>Steel</b>		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A36	--



Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	--
Tubing, hot-formed	A501	--
Steel pipe	A53	Grade B
<b>Stainless Steel</b>		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
<b>Aluminum</b>		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B209	Alloy 6061-T6
Structural aluminum	B209 B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

## 2.02 MANUFACTURED UNITS

- A. Aluminum grating stair tread:
  1. Manufacturers: One of the following or equal:
    - a. Harsco Industrial IKG, Aluminum Grating Stair Tread with Mebac® nosing.
    - b. McNichols Co., Type A-Standard with Corrugated Angle Nosing.
  2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers.
  3. Size:
    - a. Tread width: To equal tread spacing plus 1 inch minimum.
    - b. Tread length: Length to suit stringer-to-stringer dimension on the Drawings.
    - c. Depth: 1-3/4 inches.



4. Bolts: Type 316 stainless steel.
- B. Aluminum stair nosing:
1. Manufacturers: One of the following or equal:
    - a. Wooster Products, Inc., Type 101 Nosing.
    - b. American Safety Tread Co., Inc., Style 801 Nosing.
  2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
  3. For installation in cast-in-place stairs.
  4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.
- C. Cast iron stop plank grooves:
1. Manufacturers: One of the following or equal:
    - a. Neenah Foundry Co., R-7500 Series, Type A.
    - b. McKinley Iron Works, Type L.
  2. Size: 2-inch wide groove opening by 1-1/2 inch deep, unless otherwise indicated on the Drawings.
  3. Recess groove with the cast iron surface of the groove set flush with the concrete surface.
- D. Concrete inserts:
1. Concrete inserts for supporting pipe and other applications are specified in Section 15061 - Pipe Supports.
- E. Handrails and guardrails:
1. General:
    - a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
    - b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
      - 1) Indicate on the shop drawings locations of such equipment.
      - 2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.
  2. Aluminum handrails and guardrails (nonwelded pipe):
    - a. Rails, posts, and fitting-assembly spacers:
      - 1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
    - b. Kick plates: 6061 or 6105 aluminum alloy.
    - c. Fastenings and fasteners: As recommended or furnished by the manufacturer.
    - d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
      - 1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
        - a) Bases: 6061 or 6063 extruded aluminum alloy.
      - 2) Plug screws or blind rivets: Type 305 stainless steel.
        - a) Other parts: Type 300 series stainless steel.



- e. Finish of aluminum components:
    - 1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    - 2) Pretreat aluminum for cleaning and removing markings before anodizing.
  - f. Fabrication and assembly:
    - 1) Fabricate posts in single, unspliced pipe length.
    - 2) Perform without welding.
    - 3) Do not epoxy bond the parts.
    - 4) Maximum clear opening between assembled railing components as indicated on the Drawings.
  - g. Manufacturers: One of the following or equal:
    - 1) Moultrie Manufacturing Co., Wesrail.
    - 2) Golden Railings, Riveted System.
    - 3) Craneveyor Corp. Enerco Metals, C-V Rail.
  - 3. Steel pipe handrails and guardrails:
    - a. Schedule 40 black steel pipe with minimum 1.9-inch outside diameter, or larger where indicated on the Drawings.
    - b. Fabricate posts in single, unspliced pipe length.
    - c. Kick plates: Galvanized steel.
    - d. Attachment devices: Provide clip angles and other fasteners necessary for securing handrails and guardrails to other construction as indicated on the Drawings.
    - e. Continuously weld joints and grind smooth.
    - f. Bend rails to profile indicated on the Drawings, without sharp bends or flat spots. Rails shall be round after bending.
    - g. Neatly weld intersection of rails and posts, and grind surfaces smooth.
  - 4. Guardrail gates:
    - a. Supplied by guardrail manufacturer:
      - 1) Of same material, quality, and workmanship as specified for guardrail system in which they will be installed.
      - 2) Of design similar to that of handrail or railing system in which they will be installed.
    - b. Components: Gate frame, stainless steel self-closing device, hinges, gate stops, and durable self-locking type latch. Fabricate components in conformance with OSHA minimum strength requirements.
  - 5. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.
- F. Ladders:
- 1. General:
    - a. Type: Safety type conforming to local, State, and OSHA standards as minimum. Furnish guards for ladder wells.
    - b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
  - 2. Aluminum ladders:
    - a. Materials: 6063-T5 aluminum alloy.
    - b. Rungs:
      - 1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.



- 2) Capable of withstanding 1,000 pound load without failure.
  - c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
  - d. Finish of aluminum components:
    - 1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    - 2) Pretreat aluminum for cleaning and removing markings before anodizing.
  - e. Fabrication:
    - 1) Welded construction, of size, shape, location, and details indicated on the Drawings.
    - 2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and OSHA requirements.
  - f. Fall prevention system: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements:
    - 1) Manufacturers: One of the following or equal:
      - a) North Consumer Products, Saf-T-Climb.
      - b) Swager Communications, Climbers Buddy System.
- G. Manhole frames and covers:
  - 1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
  - 2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
  - 3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
  - 4. Frame:
    - a. Bottom flange type.
    - b. Approximately 4-1/2 inches frame height.
    - c. Dimensions as indicated on the Drawings.
      - 1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
  - 5. Cover:
    - a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as "ELECTRICAL," "SEWER," "TELEPHONE," or "WATER."
    - b. Solid type without ventilation holes.
  - 6. Finish: Unpainted.
- H. Manhole steps:
  - 1. Type 316 stainless steel, of size, shape, and spacing indicated on the Drawings.
- I. Metal gratings:
  - 1. General:
    - a. Fabricate grating to cover areas indicated on the Drawings.
    - b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    - c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    - d. Band ends of grating and edges of cutouts in grating:



- 1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
- 2) Cutout banding: Full-height of grating.
- 3) Use banding of same material as grating.
- 4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
- 5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
- 6) Openings smaller than 6 inches: Locate opening at edge of single panel.
- 7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
- 8) Fabricate steel grating sections in units weighing not more than 150 pounds each.
- 9) Fabricate aluminum grating sections in units of weighing not more than 150 pounds each.
- 10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.
- e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
  - 1) Furnish a suitable dial gauge for measuring deflections.
- f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.
2. Aluminum grating:
  - a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
  - b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
  - c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
  - d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
  - e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
  - f. Maximum fiber stress for design load: 12,000 pounds per square inch.
  - g. Maximum deflection due to design load: 1/240 of grating clear span.
  - h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
  - i. Minimum grating height: 1-1/2 inches.
  - j. Manufacturers: The following or equal:
    - 1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.
3. Steel gratings:
  - a. Hot-dip galvanized in accordance with ASTM A123.
  - b. Bar size and spacing: As determined by the manufacturer to support design load.
  - c. Design live load: A minimum of 100 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
  - d. Maximum fiber stress for design load: 18,000 pounds per square inch.
  - e. Maximum deflection under design load: 1/240 of grating clear span.
  - f. Bar spacing: Maximum of 1-1/8 inches clear between bars.
  - g. Manufacturers: The following or equal:



- 1) Harsco Industrial IKG, IKG Weldforged.
4. Heavy-duty steel grating:
  - a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
  - b. Hot-dip galvanized after fabrication in accordance with ASTM A123.
  - c. Manufacturers: One of the following or equal:
    - 1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
    - 2) Seidelhuber Metal Products, Inc., equivalent product.
- J. Metal tread plate:
  1. Plate having a raised figured pattern on 1 surface to provide improved traction.
- K. Preformed channel pipe supports:
  1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 15062 - Preformed Channel Pipe Support System.
- L. Stairs:
  1. Aluminum stairs:
    - a. Stringers: 6061-T6 aluminum alloy.
    - b. Stair treads:
      - 1) Aluminum of same type specified under Aluminum Grating.
      - 2) Of sizes indicated on the Drawings, and 1-3/4 inch minimum depth with cast abrasive type safety nosings.
    - c. Handrails and guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Nonwelded Pipe).
    - d. Fasteners: Type 304 or Type 316 stainless steel.
  2. Steel stairs:
    - a. Ships ladders shall conform to local, State, and OSHA as minimum.
    - b. Stringers: Structural steel channels or plates.
    - c. Treads: Open type attached to stringers with support angles and clips. Manufacturers: One of the following or equal:
      - 1) Harsco Industrial IKG, "Welded Tread" with Algrip® nosing.
    - d. Railings: Steel pipe, sized as indicated on the Drawings.
    - e. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
    - f. Finish: Prime paint finish for interior locations.
- M. Miscellaneous aluminum:
  1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
  2. Do not weld or flame cut.
- N. Miscellaneous cast iron:
  1. General:
    - a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
    - b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
    - c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.





- O. Miscellaneous stainless steel:
1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
    - a. Fabricate and install in accordance with the best practices of the trade.
  2. Cleaning and passivation:
    - a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
    - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
    - c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
      - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
    - d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
      - 1) Passivation by citric acid treatment is not allowed.
        - a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
      - 2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
      - 3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
    - e. After cleaning, inspect using methods specified for "gross inspection" in ASTM A380.
    - f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.
- P. Miscellaneous structural steel:
1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
    - a. Fabricate and install in accordance with the best practices of the trade.
- Q. Isolating sleeves and washers:
1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verification of conditions:
1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
  2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.





## 3.02 INSTALLATION

- A. General:
  - 1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
  - 2. Interface between materials:
    - a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
      - 1) Make application so that the isolating or protective barrier is not visible in the completed construction.
      - 2) Isolating sleeves and washers: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    - b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09960 - High Performance Coatings.
    - c. Aluminum in contact with concrete or masonry.
- B. Aluminum stair nosing:
  - 1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
  - 2. Omit stair nosings where concrete is submerged.
  - 3. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step.
- C. Cast iron stop plank grooves:
  - 1. Recess stop plank grooves with cast iron surfaces of groove set flush with concrete surface.
- D. Handrails and guardrails:
  - 1. General:
    - a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
    - b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
    - c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
    - d. Space attachment brackets as indicated in the manufacturer's instructions.
  - 2. Aluminum pipe handrails and guardrails:
    - a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.
    - b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
    - c. Discontinue handrails and guardrails at lighting fixtures.
    - d. Provide 1/8-inch diameter weep hole at base of each post.
    - e. Space posts as indicated on the Drawings.
    - f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
    - g. Space rails as indicated on the Drawings.



- h. Make adequate provision for expansion and contraction of kick plates and rails.
            - 1) Make provisions for removable sections where indicated on the Drawings.
          - i. Make lower rails a single, unspliced length between posts, or continuous.
          - j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
          - k. Draw up fasteners tight with hand wrench or screw driver.
          - l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
          - m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
          - n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
          - o. Replace damaged or disfigured handrails and guardrails with new.
          - p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
            - 1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
          - q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.
  - 3. Steel pipe handrail and guardrail:
    - a. Anchor posts into concrete by grouting posts into galvanized steel sleeves embedded in concrete as indicated on the Drawings.
      - 1) Do not cut reinforcing bars in concrete.
      - 2) Where required to fasten guardrail to other construction, fasten as indicated on the Drawings.
  - 4. Guardrail gates:
    - a. Install gate to be a vertical plane with the guardrail when in the closed position.
    - b. Install hinges so that each gate can swing 180 degrees from the closed position to the fully open position.
    - c. Install so that the gates swing to the walkway side of the guardrail only.
      - 1) Install gate stops on the stationary railing posts to prohibit gates from swinging in the wrong direction.
    - d. Install gate frames, hinges, stops, and latches in conformance with OSHA minimum strength requirements.
- E. Ladders:
- 1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
  - 2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
  - 3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
  - 4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
    - a. Correct deviations from true line or grade which are visible to the eye.



- F. Manhole frames and covers:
  - 1. Installation: As specified in Section 02084 - Precast Drainage Structures.
- G. Manhole steps:
  - 1. Space as indicated on the Drawings.
- H. Metal gratings:
  - 1. General:
    - a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
    - b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
    - c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
    - d. Install angle stops at ends of grating.
    - e. Installed grating shall not slide out of rebate or off support.
    - f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
    - g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
  - 2. Aluminum grating:
    - a. Aluminum grating: Support on aluminum shelf angles or rebates.
  - 3. Steel grating:
    - a. Support on hot-dip galvanized structural steel shelf angles or rebates.
  - 4. Heavy-duty steel grating:
    - a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
    - b. Use for roadways, traffic areas, and where indicated on the Drawings.
- I. Stairs:
  - 1. General:
    - a. Install guard railings around stair wells as indicated on the Drawings or specified.
- J. Stainless Steel:
  - 1. Welding:
    - a. Passivate field-welded surfaces:
      - 1) Provide cleaning, pickling and passivating as specified in this Section.
      - 2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION





## SECTION 09960

### HIGH-PERFORMANCE COATINGS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
1. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
  2. D2200 – Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
  3. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
  4. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
  5. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
  6. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
  7. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
  8. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
  9. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
  10. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
  11. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
  12. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.
  13. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
  14. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
  15. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
  16. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.
- B. International Concrete Repair Institute (ICRI):
1. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.



- C. NACE International (NACE):
  - 1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
  - 2. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
- D. National Association of Pipe Fabricators (NAPF):
  - 1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
- E. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.
- F. Occupational Safety and Health Administration (OSHA).
- G. Society of Protective Coatings (SSPC):
  - 1. Glossary - SSPC Protective Coatings Glossary.
  - 2. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
  - 3. Guide 15 - Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
  - 4. PA 1 - Shop, Field, and Maintenance Painting of Steel.
  - 5. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
  - 6. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
  - 7. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
  - 8. SP 1 - Solvent Cleaning.
  - 9. SP 3 - Power Tool Cleaning.
  - 10. SP 5 - White Metal Blast Cleaning.
  - 11. SP 10 - Near-White Metal Blast Cleaning.
  - 12. SP 11 - Power Tools Cleaning to Bare Metal.
  - 13. SP 13 - Surface Preparation of Concrete.
  - 14. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
  - 15. SP COM - Surface Preparation Commentary.
  - 16. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
  - 17. SP WJ-1 - Waterjet Cleaning of Metals -- Clean to Bare Substrate.
  - 18. SP WJ-2 - Waterjet Cleaning of Metals -- Very Thorough Cleaning.
  - 19. SP WJ-3 - Waterjet Cleaning of Metals -- Thorough Cleaning.
  - 20. SP WJ-4 - Waterjet Cleaning of Metals -- Light Cleaning.

### 1.03 DEFINITIONS

- A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.
- B. Specific definitions:
  - 1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
  - 2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.



3. Anchor Pattern: Profile or texture of prepared surface(s).
4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
6. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
7. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
8. Dew point: Temperature a given air/water vapor mixture starts to condense.
9. Drying Time: Time interval between application and material curing.
10. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
11. Dry to Touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
12. Exposed Surface: Any indoor or outdoor surface not buried or encased.
13. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
14. Feathering: Tapering off a wet edge with a comparatively dry brush.
15. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
16. Field Coat: Application of a surface coating system at the work site.
17. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
18. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
20. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
21. Hydroblast: High or ultra-high pressure water jet surface preparation.
22. Incompatibility: One coating's inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
23. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
24. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
25. Mil: 0.001 inch.
26. Overspray: Dry spray, particularly paint bonded to an unintended surface.
27. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
28. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
29. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.





30. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
31. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
32. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
33. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
34. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
35. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
36. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

#### **1.04 ABBREVIATIONS**

- A. CSM - Coating System Manufacturer.
- B. CMU - Concrete Masonry Units.
- C. CSA - Coating System Applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.
- D. CTR - Coating System Manufacturer's Technical Representative.
- E. DFT - Dry-Film Thickness. Thickness of cured film, usually expressed in mils (0.001 inch).
- F. SSD - Surface Saturated Dry. Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.
- G. TPC - Technical Practice Committee.
- H. VOC - Volatile Organic Compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.





- I. WFT - Wet Film Thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

## **1.05 PERFORMANCE REQUIREMENTS**

- A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.
- B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

## **1.06 SUBMITTALS**

- A. As specified in Section 01330 - Submittal Procedures, submit the following:
1. Schedule of proposed coating materials.
  2. Schedule of surfaces to be coated with each coating material.
  3. Dehumidification and heating plan.
  4. Product data:
    - a. Physical properties of coatings, including the following:
      - 1) Solids content.
      - 2) Ingredient analysis.
      - 3) VOC content.
      - 4) Temperature resistance.
      - 5) Typical exposures and limitations.
      - 6) Manufacturer's standard color chips.
    - b. Compliance with regulatory requirements:
      - 1) VOC limitations.
      - 2) Lead compounds and polychlorinated biphenyls.
      - 3) Abrasives and abrasive blast cleaning techniques and disposal.
      - 4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
      - 5) NSF certification of coatings for potable water supply systems.
    - c. CSM's current printed recommendations and product data sheets for coating systems, including:
      - 1) Surface preparation recommendations.
      - 2) Primer type.
      - 3) Maximum dry and wet-mil thickness per coat and number of coats.
        - a) Coating Coverage Worksheets.
      - 4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
      - 5) Curing time before submergence in liquid.
      - 6) Thinner to be used for each coating.
      - 7) Ventilation requirements.
      - 8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
      - 9) Allowable application methods.
      - 10) Maximum allowable substrate moisture content.
      - 11) Maximum shelf life.
      - 12) Requirements for transportation and storage.
      - 13) Mixing instructions.
      - 14) Shelf life.
      - 15) Material Pot life.



- 16) Precautions for applications free of defects.
- 17) Method of application.
- 18) Drying time of each coat, including prime coat.
- 19) Compatible prime coats.
- 20) Limits of ambient conditions during and after application.
- 21) Required protection from sun, wind, and other conditions.
- 22) Touch-up requirements and limitations.
- 23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.
- d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
- e. Affidavits signed by an officer of the CSM's corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
- f. List of cleaning and thinner solutions allowed by the CSMs.
- g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
- h. Thick film coating systems (greater than 25 mils):
  - 1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
  - 2) Include detail treatment for coating system at concrete joints.
  - 3) Manufacturer's Representative's (CTR) Field Reports.
5. Quality assurance submittals:
  - a. Quality assurance plan.
  - b. Qualifications of CSA, including:
    - 1) List of Similar Projects.
      - a) Name and address of project.
      - b) Year of installation.
      - c) Year placed in operation.
      - d) Point of contact: Name and phone number.
    - 2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
  - c. CSA Reports:
    - 1) Written daily quality control inspection reports.
  - d. CTR Reports:
    - 1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
    - 2) Reports on visits to project site to observe and approve coating application procedures.
    - 3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

## 1.07 QUALITY ASSURANCE

- A. CSA qualifications:
  1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:



- a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
  2. SSPC QP 1 certified.
  3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.
- B. CTR qualifications:
  1. Certification, one of the following:
    - a. NACE Level 2 or 3 Certified Coating Inspector.
    - b. SSPC Level 3 Protective Coatings Inspector.
  2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
    - a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.
- C. Regulatory requirements: Comply with governing agencies' regulations by using coatings conforming to their VOC limits.
  1. Lead-based coatings are not permitted.
  2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.
- D. Certification:
  1. Certify that applicable pigments resist deterioration when exposed to hydrogen sulfide and other sewage gases.
  2. Product data shall designate coating as being suitable for wastewater service.
- E. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.
  1. Coordinate Hold Point schedule
- F. Field samples:
  1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
  2. Approved field sample may be part of the Work.
- G. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.
- H. CSM services:
  1. CSA shall arrange for CTR to attend pre-installation conferences.
  2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
  3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
  4. CTR shall provide written inspection reports.
- I. Quality control requirements:
  1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
    - a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor's responsibilities.



2. Conform to this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
3. Specially trained crews with experience applying the specified coating system coating are required for:
  - a. Coating application using plural component spray equipment or other specialty equipment.
  - b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
4. CTR shall specially train personnel for coating systems as specified in Appendix B Coating Detail Sheets.
  - a. CSM shall approve personnel in writing applying the coating system.
5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
6. Identify inspection access points used by Owners or Engineers.
7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer's personnel to safely access the work areas.
8. Conduct and continually inspect work so the coating system is installed as specified. The CSM shall provide written directions to correct coating work not conforming to the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
  - a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
    - 1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    - 2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
  - b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
    - 1) ASTM D4262.
    - 2) ASTM D4263.
    - 3) ASTM D4417.
    - 4) ICRI 310.2 requirements.
    - 5) SSPC Surface Preparation Standards.
  - c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
  - d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
  - e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
  - f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc. during coating.
    - 1) Perform WFT measurements in accordance with ASTM D4414.



- g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces. Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM's written instructions. Perform all applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

J. Inspection at Hold Points:

1. Conduct inspections at Hold Points during the coating system application and record the results.
2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor's inspections on a scheduled basis.
3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
4. Hold Points shall be as follows:
  - a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
  - b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM's written instructions.
  - c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
  - d. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
    - 1) Observe conditions during the Pre-application Meeting.

## **1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING**

- A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.
- B. Immediately remove unspecified and unapproved coatings from Project site.
- C. Deliver new labeled, unopened containers:
  1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM's recommendations.
    - a. Store flammable materials in accordance with federal, state, and local requirements.
    - b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
  2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.



3. Container labels shall show the following:
  - a. Brand name or product title.
  - b. CSM's batch number.
  - c. CSM's manufacture date.
  - d. CSM's name.
  - e. Generic material type.
  - f. Application and mixing instructions.
  - g. Hazardous material identification label.
  - h. Shelf life expiration date.
  - i. Color.
  - j. Mixing and reducing instructions.
4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

## 1.09 PROJECT CONDITIONS

- A. Apply coatings to dry surfaces.
  1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section.
    - a. Plaster and gypsum wallboard: 12 percent.
    - b. Masonry and concrete block: 12 percent.
    - c. Interior located wood: 15 percent.
    - d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
    - e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.
- B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
  1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
  2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
  3. When ambient or surface temperature:
    - a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
    - b. Is less than 65 degrees Fahrenheit for clear finishes, unless manufacturer allows a lower temperature.
    - c. Exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
    - d. Exceeds manufacturer's recommendation.
  4. When relative humidity is higher than 85 percent.
  5. Under dusty or adverse environmental conditions.
  6. When light on surfaces measures less than 15 foot-candles.
  7. When wind speed exceeds 15 miles per hour.





- C. Apply coating only under evaporation conditions rather than condensation.
  - 1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
  - 2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
    - a. Submit test results.
- D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
  - 1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
  - 2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
  - 3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
  - 4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
  - 5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
    - a. Entire curing period.
    - b. 8 hours after coating.
- E. Systems:
  - 1. Site electrical power availability as specified in Section 01500 - Temporary Facilities and Controls.
  - 2. Internal combustion engine generators may be used.
    - a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
    - b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
    - c. Locate engine generator outside hazardous classified areas per NFPA 820.
    - d. Provide daily fuel service for generator for duration of use.
  - 3. Dehumidification:
    - a. Provide desiccant or refrigeration drying.
    - b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
    - c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
  - 4. Heating:
    - a. Use electric, indirect combustion, or steam coil.
    - b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
  - 5. Filters:
    - a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
    - b. Do not allow air from the working area or dust filtration equipment to recirculate through the dehumidifier during coating application or when solvent vapors are present.



6. Design and submittals:
  - a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
  - b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.
- F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

## **1.10 MAINTENANCE**

- A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

## **1.11 CTR RESPONSIBILITIES**

- A. General:
  1. Attend pre-installation conference.
  2. Perform onsite application training.
  3. Periodically inspect coating system application.
- B. Coating system installation training:
  1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
    - a. Train a minimum of 2 supervisory personnel and 2 application personnel.
    - b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
  2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
  3. Minimum training requirements:
    - a. Explain in detail the mixing, application, curing, and termination requirements.
    - b. Provide hands-on demonstration of coating system mixing.
    - c. Explain in detail the ambient condition requirements for temperature and humidity.
    - d. Explain in detail the surface preparation requirements.
    - e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
    - f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
  4. Provide special training as specified in the Coating Detail Sheets.
- C. Coating system inspection:
  1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
  2. Be on-site to oversee:
    - a. Coating application at least once a week.
    - b. End of surface preparation.
    - c. During coating application.
    - d. Post-cure inspection.





3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
4. Perform the following activities to confirm conformance with the specifications:
  - a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
  - b. Inspect each coated surface type and coating system applied to verify the following:
    - 1) Cleanliness.
    - 2) Surface pH for concrete substrates.
    - 3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
  - c. Verify surface profile of substrates by completing the following:
    - 1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
    - 2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
    - 3) Verify proper mixing of coating materials.
    - 4) Inspect application of primers and finish coats, including wet and dry film thickness.
    - 5) Inspect coating systems for proper cure times and conditions.
  - d. Review adhesion testing of cured coating systems.
  - e. Review coating system continuity testing.
  - f. Inspect and record representative-localized repairs.
  - g. Conduct final review of completed coating system installation.
  - h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM's Recommendations.

D. Final report:

1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits. Include a statement that completed work was performed in accordance with the requirements of the CSM's recommendations.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

A. General:

1. Product requirements as specified in Section 01600 - Product Requirements.

### **2.02 COATING SYSTEMS IDENTIFICATION**

- A. Naming Conventions: Coating Systems Identifications contain the elements defined in Table 1.



**Table 1 Coating System Identification Elements**

First Element	-	Second Element	-	Third Element	-	Fourth Element (optional)
3 or 4 alpha characters		1-3 alpha characters		1 number		3 or 4 alpha characters
Coating Type		Substrate		System Number		Additional Substrate or Special Condition
Example: EPX	-	C	-	6	-	BSC

- 1) First element identifies the coating type using the following abbreviations:
  - a) ACR: acrylic.
  - b) CTE: coal tar epoxy.
  - c) ELA: elastomeric acrylic.
  - d) EPU: epoxy-polyurethane.
  - e) EPX: epoxy.
  - f) POL: polyurethane.
  - g) SIL: silicone.
  - h) SILX: siloxane or silane.
  - i) VE: vinyl ester.
- 2) Second element identifies the substrate using the following abbreviations:
  - a) C: concrete or masonry.
  - b) F: concrete flooring.
  - c) FRP: fiber-reinforced plastic.
  - d) GM: galvanized metal.
  - e) M: metal.
  - f) PVC: polyvinyl chloride, chlorinated polyvinyl chloride.
- 3) Third element identifies the sequential system number.
  - a) For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
- 4) Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
  - a) PWS: Potable water service applications (NSF-61 approved).
  - b) BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
  - c) BG: Below grade or buried.
  - d) OZ: Organic zinc primer, epoxy polyurethane system.
  - e) SC: Secondary containment.

## 2.03 PRODUCTS FOR COATING SYSTEMS

- A. Products: As specified in Appendix B Coating Detail Sheets.
- B. Cleaning solvents:
  1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
    - a. Emulsifying type.
    - b. Containing no phosphates.
    - c. Biodegradable.
    - d. Does not damage zinc.



- e. Compatible with the specified primer.
  - f. Complying with applicable air-quality control board requirements.
2. Use clean white cloths and clean fluids in solvent cleaning.

## **PART 3 EXECUTION**

### **3.01 GENERAL PROTECTION REQUIREMENTS**

- A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.
- B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.
- C. Mask off surfaces of items not to be coated or remove items from area.
- D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.
- E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.
- F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application. Carefully store, clean, and replace items after completing coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.
- G. Erect and maintain protective enclosures in accordance with SSPC- Guide 6.
- H. Protect the following surfaces from abrasive blasting by masking or by other means:
  1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
  2. Machined surfaces for sliding contact.
  3. Surfaces to be assembled against gaskets.
  4. Surfaces of shafting where sprockets will be fit.
  5. Surfaces of shafting where bearings will be fit.
  6. Machined bronze surfaces, including slide gates.
  7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
  8. Galvanized items, unless scheduled to be coated.
- I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.



- J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
  2. After completing coating, reinstall removed items.
  3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

### **3.02 GENERAL SURFACE PREPARATION REQUIREMENTS**

- A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.
- B. Coating detail sheets in Appendix B include additional surface preparation requirements.
- C. Follow more stringent requirement if information conflicts.
- D. Where required by the Owner's representative, a NACE International certified coatings inspector, provided by the Engineer, will inspect and approve surfaces to be coated before applying a coating.
1. CSA shall coordinate coating inspections.
    - a. Identify coating inspection Hold Points during the pre-installation conference.
    - b. Provide at least 2 days notice before inspection.
  2. Contractor shall correct surface defects identified by the inspector at no additional cost to Owner.

### **3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION**

- A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 - Equipment Identification, Section 15076 - Pipe Identification, and Section 16075 - Identification for Electrical Systems.
- B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.
- C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the Owner.
- D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.
- E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.
- F. Prepare and coat interior surfaces of air ducts and convectors and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.



- G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.
- H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.
- I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.
- J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

### **3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES**

- A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
  - 1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
  - 2. Manufacturers: The following or equal:
    - a. CHLOR\*RID International, Inc.
      - 1) Complete soluble salt removal with steam or warm water cleaning.
  - 3. Steam clean and degrease surfaces to be coated to remove oils and grease.
  - 4. Clean surfaces with decontamination agent in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing, as approved by the CTR and the Engineer.
  - 5. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
  - 6. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

### **3.05 BLAST CLEANING**

- A. Surface preparation requirements:
  - 1. Do not reuse spent blast abrasive.
  - 2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
  - 3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
  - 4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.
  - 5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
  - 6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.



7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
  8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.
- B. Water jetting or water blasting:
1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
  2. Perform water jetting or water blasting in accordance with SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

### **3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES**

- A. Cure for at least 28 days before coating.
- B. Remove degraded concrete using abrasive blast cleaning or high or ultrahigh pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove all bruised or cracked concrete.
- C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges per the CSM's recommendations and as indicated on the Drawings.
1. Prepare concrete surfaces in accordance with SSPC-SP 13.
- D. Prepare concrete surfaces in accordance with SSPC-SP 13.
1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
  2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
  3. Repair concrete defects and physical damage.
  4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
  5. Fill voids to provide surface as specified in Section 03366 - Tooled Concrete Finishing.
- E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
  2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
- F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.



2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.
- G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.
- H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.
- I. Vacuum all concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
  1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
  2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.
- J. Test moisture content of concrete to be coated:
  1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
    - a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
  2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
  3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
    - a. Waterproof surfaces exposed to soil or water where specified in Section 07110 - Dampproofing.
  4. Comply with specified minimum moisture content and CSM's written recommendations for moisture vapor transmission rates or relative humidity values.
- K. Masonry surfaces:
  1. Cure for at least 28 days before coating.
  2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
  3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
  4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
  5. Confirm that masonry surfaces are dry before coating application.
    - a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

### **3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES**

- A. Remove rust, scale, and welding slag and spatter.
  1. Remove and grind smooth all excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.





2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.
- B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
  1. Remove grease and oil in accordance with SSPC-SP 1.
  2. Use solvent as recommended by the CSM.
  3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Contractor shall select blast particle size and gradation to produce the specified surface profile.
  4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no "rust back" occurs before coating material application.
- C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.
- D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
  1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
  2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
  3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
  4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.
- E. Field preparation of shop-primed surfaces:
  1. Smooth welds and prominences with power tools before applying field-applied coatings.
  2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
  3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
    - a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
  4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
  5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).
- F. Damaged shop primer or rust bleeding:
  1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
  2. Reject galvanized steel with rust bleeding.





- G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

### **3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE**

- A. Galvanized steel and non-ferrous metal surfaces:
1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
  2. Abrasive blast clean in accordance with SSPC-SP 16.
    - a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
  3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
  4. Test surface for contaminants using copper sulfate solution.
- B. Stainless-steel surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.
- C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.
- D. Sherardized, aluminum, copper, and bronze surfaces:
1. Abrasive blast clean in accordance with SSPC-SP 16.
  2. Prepare in accordance with CSM's instructions.
- E. Cadmium-plated, zinc-plated, or sherardized fasteners:
1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.
- F. PVC and FRP surfaces:
1. Lightly sand surfaces to be coated.
    - a. Sand to remove gloss and establish uniform surface profile.
  2. Vacuum to remove loose dust, dirt, and other materials.
  3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

### **3.09 APPLICATION REQUIREMENTS**

- A. Apply coatings in accordance with manufacturer's instructions.
- B. Empty aboveground piping to be coated of contents when applying coatings.
- C. Mechanical equipment shop primed by the manufacturer.
1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
    - a. Contractor shall provide CTR shop coating reports.
  2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
    - a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
  3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.



- D. Verify surface preparation immediately before applying coating in accordance with SSPC SP COM and the SSPC visual standard for the specified surface preparation method.
- E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.
- F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.
- G. Do not apply coatings to a surface until it has been prepared as specified.
- H. Use equipment designed to apply materials specified.
  - 1. Use compressors with moisture traps and filters that remove water and oils from the air.
    - a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
  - 2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.
- I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
  - 1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.
- J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
  - 1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
  - 2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
  - 3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.
- K. Spray application:
  - 1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
  - 2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
  - 3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
  - 4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.
- L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.
- M. Remove all dust on coatings between coats.



- N. Shop and field coats:
1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
    - a. Provide data sheets identifying the shop primer to on-site coating application personnel.
    - b. Perform adhesion tests on the shop primer.
    - c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
    - d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
  2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
    - a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
  3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
    - a. Prime coat adheres to the substrate.
    - b. Coatings adhere to the prime and intermediate coats.
      - 1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
      - 2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.
- O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.
- P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
  2. Before starting application:
    - a. Verify gauges are working properly.
    - b. Complete ratio checks.
    - c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
    - d. Label and retain all spray samples. Submit to Engineer when requested.
- Q. Drying and recoating:
1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
  2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM's printed instructions, before recoating.
  3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time.
    - a. Do not allow excessive drying time or exposure, which may impair bond between coats.
    - b. Recoat all coatings within time limits recommended by CSM.
    - c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
  4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.



5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
  6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
  7. Leave no holidays. Repair all holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
  8. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.
  9. For submerged service or highly corrosive headspace service, provide a letter to the Engineer stating that the lining system is fully cured and ready to be placed into service.
- R. Workmanship:
1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
  2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
  3. Remove splatter and droppings after coating work is completed.
  4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
  5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
  6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
    - a. Brush apply stripe coat to ensure proper coverage.
    - b. Do not stripe coat with spray or roller.
  7. Ensure that finish coat, including repairs, has a uniform color and gloss.
- S. Coating properties, mixing, and thinning:
1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
  2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
  3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
  4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
  5. Mix coatings with 2 or more components in accordance with CSM's instructions.
  6. Where necessary to suit conditions of the surface, temperature, weather and method of application, thin the coating per CSM's recommendations.
    - a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
    - b. Thin coatings to only what is necessary to obtain proper application characteristics.
    - c. Use a thinner recommended by the CSM.



- T. Film thickness and continuity:
  - 1. Apply coating to the specified thicknesses.
    - a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
  - 2. Verify WFT of the coating system first coat and after applying each subsequent coat.
  - 3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
  - 4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
    - a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
  - 5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.
- U. Protecting coated surfaces:
  - 1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
  - 2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.
- V. Special requirements:
  - 1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
  - 2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
  - 3. Areas damaged during erection:
    - a. Prepare surface for spot repairs as specified for the coating system.
    - b. Recoat with prime coat before applying subsequent coats.
    - c. Touch up surfaces after installation.
    - d. Clean and dry surfaces to be coated at time of application.
  - 4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
  - 5. Coat aluminum in contact with concrete.

### **3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS**

- A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
  - 1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.
- B. Apply surfacer or filler and let dry before coating application.
  - 1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions.
    - a. Let concrete substrate dry before applying filler/surfacers or coating system materials.



2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures per CSM's instructions.
  3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
    - a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
    - b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
    - c. Provide relatively flat, uniformly even surface before coating application.
  4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes.
    - a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
    - b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.
- C. Concrete substrate temperatures:
1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
    - a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
  2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
    - a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
    - b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.
- D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and drawings, whichever is stricter.
- E. Concrete coating systems application requirements:
1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

### **3.11 COATING SYSTEM SCHEDULE**

- A. Appendix A specifies surfaces to be coated in the field with the coating systems required.

### **3.12 SURFACES NOT REQUIRING COATING**

- A. Stainless steel piping, valves, pipe supports, instrument sunshades.
- B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.
- C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.





- D. Copper and brass pipe, fittings, valves, etc.
- E. Bronze valves, bearings, bushings, and fasteners.
- F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.
- G. Exterior Concrete.
- H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.
- I. Buried Piping that is encased in concrete or cement mortar.

### **3.13 QUALITY CONTROL**

- A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.
- B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
  - 1. Inspect materials upon receipt to ensure that the CSM supplied them.
  - 2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
  - 3. Inspect and record findings for substrate cleanliness.
  - 4. Inspect and record pH of concrete and metal substrates.
  - 5. Inspect and record substrate profile (anchor pattern).
  - 6. Measure and record ambient air and substrate temperature.
  - 7. Measure and record relative humidity.
  - 8. Check for substrate moisture in concrete.
  - 9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
  - 10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
  - 11. Perform adhesion testing.
  - 12. Measure and record the coating system's thickness.
  - 13. Verify proper curing of the coating system in accordance with the CSM's instructions.
  - 14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.
- C. Contractor shall perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
  - 1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
  - 2. Coated concrete.
  - 3. Perform holiday tests after proper application and coating system cure.



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## **CORRECTIVE MEASURES**

- A. Repair pinholes or holidays identified by Holiday Testing as follows:
  - 1. Remove the coating system with a grinder or other suitable power tool.
  - 2. Remove coating system at all pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
  - 3. Concrete voids: chip back to expose entire cavity in all directions.
    - a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool, and strike off. Cure per CSM's recommendations.
  - 4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
  - 5. Vacuum the prepared area to remove all dust, dirt, etc., leaving clean, sound surfaces.
  - 6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
  - 7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
  - 8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast per CSM's instructions, if the maximum recoat time is exceeded.
  - 9. Apply coating at specified dry film thickness.

### **3.15 CLEANUP**

- A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

### **3.16 FINAL INSPECTION**

- A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.
- B. Conduct subsequent final inspection with Engineer to ensure work conforms to contract documents requirements.
- C. Mark any rework required.
  - 1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION





## **SECTION 10400**

### **SIGNAGE**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Plastic and metal signs for building and site use.

##### **1.02 REFERENCES**

- A. National Fire Protection Association (NFPA):
  - 1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.
- B. Occupational Safety and Health Administration (OSHA).

##### **1.03 SUBMITTALS**

- A. Product data:
- B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.
- C. Samples: Include actual materials.
- D. Manufacturer's installation instructions.

##### **1.04 QUALITY ASSURANCE**

- A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.
- B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.
- C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

#### **PART 2 PRODUCTS**

##### **2.01 PLASTIC SIGNAGE SYSTEM**

- A. Manufacturers:
  - 1. One of the following or equal:
    - a. Best Manufacturing Sign Systems, System 900013.
    - b. Andco Industries Corp., equivalent product.



c. Vomar Products, Inc., equivalent product.

- B. Attachment:
  - 1. Vinyl tape, self-adhering.
- C. Lettering:
  - 1. Helvetica medium, 3/4 inches high.
- D. Material for interior use:
  - 1. Plastic 1/8-inch thick raised letters.
- E. Material for exterior use:
  - 1. Fiberglass 1/4 inch thick with high gloss finish, raised letters, blasted from single piece of fiberglass for integral letter and background.
  - 2. No adhesive as mechanical fastening of letters shall be allowed.
- F. Colors:
  - 1. As selected by Engineer from manufacturer's standard colors.
- G. See Schedule A for specific sign size, location, text, pictogram, and quantity.

## **2.02 METAL SAFETY SIGNS**

- A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
  - 1. Seton Name Plate Co., Special Wording.
  - 2. Emedco.
- B. Danger sign colors:
  - 1. Background: White.
  - 2. Heading: White lettering on red oval with white border in black rectangular panel.
  - 3. Message: Black lettering on white.
  - 4. Size: As scheduled.
- C. Caution sign colors:
  - 1. Background: Yellow.
  - 2. Heading: Yellow lettering on black rectangular panel.
  - 3. Message: Black lettering on yellow.
  - 4. Size: As scheduled.
- D. Safety instruction signs:
  - 1. Background: White.
  - 2. Heading: White lettering on green rectangular panel.
  - 3. Message: Black lettering.
  - 4. Size: As scheduled.
- E. Warning sign colors:
  - 1. Background: Orange.
  - 2. Heading: Black lettering on orange diamond in black rectangular panel.
  - 3. Message: Black lettering on orange.
  - 4. Size: As scheduled.



- F. Notice information signs:
  - 1. Background: White.
  - 2. Heading: White lettering on blue rectangular panel.
  - 3. Message: Black lettering.
  - 4. Size: As scheduled.
- G. Fasteners: Round head stainless steel bolts or screws.
- H. See Schedule B for specific sign size, location, text, and quantity.

### **2.03 EXTERIOR INFORMATION SIGNS**

- A. Able to withstand 100 miles per hour wind load without damage:
  - 1. Manufacturers: One of the following or equal:
    - a. Best Manufacturing Sign Systems; equivalent product.
    - b. Andco Industries Corp., equivalent product.
    - c. Vomar Products, Inc., equivalent product.
- B. Sign panel: Nominal 3 inches thick, consisting of 1/8-inch thick fiberglass material with integral returns fully encapsulating wood and foam core, 1/8-inch radius edges and corners, size as indicated on the Drawings.
- C. Text: Helvetica medium, size and wording as indicated on the Drawings.
- D. Posts: Nominal 3 inch square extruded aluminum sections with aluminum fillers at top and bottom, mounting hardware, and aluminum baseplates drilled for anchor bolts.
- E. Fasteners: Manufacturer's standard, suitable for application.
- F. Colors: As selected from manufacturer's standard colors.

### **2.04 CAST METAL PLAQUE**

- A. Manufacturers: One of the following or equal:
  - 1. Andco Industries Corp.
  - 2. Southwell Co.
  - 3. ARK-RAMOS Inc.
- B. Material: Cast bronze.
- C. Size: Approximately 28 by 34 inches by minimum 3/16 inches thick; lettering, center panel, and trim raised 1/8 inch.
- D. Lettering: Text as indicated on the Drawings. Verify before fabrication.
- E. Finishes:
  - 1. Lettering, center panel, and trim: Fine satin.
  - 2. Background: Finely pebbled, oxidized to dull black color.
- F. Mounting: Concealed with fasteners.



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## **HAZARD MATERIAL SIGNALS**

- A. Manufacturer: One of the following or equal:
  - 1. Seton Name Plate Co.
  - 2. Emedco.
- B. Hazard material signals: In accordance with NFPA 704; vinyl or 40-mil thick aluminum with baked enamel finish panels, letters, and symbols with pressure sensitive adhesive, sizes as required for viewing distances, letters and symbols in accordance with Schedule C.

## **PART 3 EXECUTION**

### **3.01 PREPARATION**

- A. Protect adjacent surfaces which may be damaged by installation of signs.
- B. Prepare substrates in accordance with sign manufacturer's instructions.
- C. Remove scale, dirt, grease, and other contaminants from substrates.

### **3.02 INSTALLATION**

- A. Install signs in accordance with sign manufacturer's instructions.
- B. Fasten signs securely in level, plumb, and true to plane positions.
- C. Install signs where indicated on the Drawings or as indicated in the following schedules.

### **3.03 SCHEDULES**

- A. Plastic Signage System Schedule.
- B. Metal Safety Sign Schedule.

END OF SECTION



## SCHEDULE A

### PLASTIC SIGNAGE SYSTEM SCHEDULE

- A. Stair Landings:
1. Location: At each floor landing in stairwells.
  2. Height: 60 inches above floor to center of sign.
  3. Size: 6 inches square.
  4. Colors: As selected by Engineer.
  5. Text: Stair number, access or no access to roof to suit application, and floor level, as follows:
- B. Fire Extinguishers:
1. Location: Adjacent to fire extinguishers.
  2. Height: 60 inches above floor to center of sign.
  3. Size: 6 inches square.
  4. Colors: White letters on OSHA Red background.
  5. Text: FIRE EXTINGUISHER.
- C. Nonpotable Water:
1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
  2. Height: In accordance with Typical Detail.
  3. Size: 10 inches wide by 7 inches high.
  4. Heading: CAUTION
  5. Text: IMPURE WATER  
DO NOT DRINK
- D. FOG Offloading Station:
1. Location: At FOG offloading control panel.
  2. Height: 60 inches above floor to center of sign.
  3. Size: 10 inches wide by 7 inches high.
  4. Heading: ATTENTION
  5. Text: DRIVER MAKE SURE THE VENT ON YOUR TANK IS OPEN BEFORE  
STARTING THE UNLOADING OPERATION. UTILITY IS NOT RESPONSIBLE FOR  
DAMAGE TO YOUR TANK.

END OF SCHEDULE A  
PLASTIC SIGNAGE SYSTEM SCHEDULE



## SCHEDULE B

### METAL SAFETY SIGN SCHEDULE

#### E. NONPOTABLE WATER:

1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
2. Height: In accordance with Typical Detail.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: DO NOT DRINK THIS WATER

#### F. HIGH PRESSURE HOSE VALVES:

1. Location: At designated hose valves.
2. Height: 60 inches above floor to center of sign.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: HIGH PRESSURE

#### G. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:

1. Location: On front and back of equipment that starts automatically by remote control.
2. Height: 60 inches above floor to center of sign.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY BY REMOTE CONTROL

#### H. HIGH VOLTAGE WARNING:

1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
2. Height: 60 inches above floor to center of sign.
3. Size: 10 inches wide by 7 inches high.
4. Heading: DANGER
5. Wording: HIGH VOLTAGE  
KEEP OUT

#### I. NO SMOKING INFORMATIONAL SIGNS:

1. Location: On exterior face of wall, adjacent to each entry point (exterior door) to all buildings.
2. Height: 60 inches above floor to center of sign. Where metal safety signs are also located adjacent to entry points, place no smoking signs below these signs.
3. Size: 6 inches square.
4. Heading: None.
5. Wording: None.
6. Pictogram: International "No Smoking" symbol.



- J. NO SMOKING WITHIN 25 FEET OF BUILDING ENTRY:
1. Location: As indicated on the Drawings.
  2. Height: Pole mounted with top of sign at 5 feet above grade.
  3. Size: 14 inches wide by 10 inches high.
  4. Heading: NOTICE
  5. Wording: NO SMOKING WITHIN 25 FEET OF BUILDING.
  6. Pictogram: International "No Smoking" symbol.

END OF SCHEDULE B  
METAL SAFETY SIGN SCHEDULE







## SECTION 13446

### MANUAL ACTUATORS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Valve and gate actuators.
  - 2. Handwheel actuators.
  - 3. Hand-cranked geared actuators.
  - 4. Floor Boxes.
  - 5. Floor stands.
  - 6. Key operated valves.
  - 7. Bench stands.
  - 8. Accessory equipment and floor boxes.

##### 1.02 REFERENCES

- A. Aluminum Association (AA):
  - 1. DAF-45 - Designation System for Aluminum Finishes.
- B. American Water Works Association (AWWA).
- C. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. National Electrical Code (NEC).

##### 1.03 DEFINITIONS

- A. NEMA:
  - 1. Type 4X enclosure in accordance with NEMA 250.
  - 2. Type 7 enclosure in accordance with NEMA 250.

##### 1.04 SUBMITTALS

- A. Shop drawings: Include shop drawings and product data with associated gate or valve as an integrated unit.

##### 1.05 QUALITY ASSURANCE

- A. Provide valve actuators integral with valve or gate, except for valve actuators utilizing T-wrenches or keys, and portable gate actuators intended to operate more than 1 valve.
- B. Provide similar actuators by 1 manufacturer.
- C. Provide gates and hand operating lifts by 1 manufacturer.



- D. Provide hydraulic gate lifts by 1 manufacturer.
- E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

## **1.06 MAINTENANCE**

- A. Extra materials:
  - 1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

## **PART 2 PRODUCTS**

### **2.01 VALVE AND GATE ACTUATORS**

- A. Valve actuators:
  - 1. Motorized actuators, and portable gate actuators are specified in 13447 - Electric Motorized Actuators.
  - 2. Manual actuators:
    - a. Material: Type 316 stainless steel.
    - b. Design: Hand lever.
    - c. Spring release handle: 12-inch.
    - d. Notch plate: 10 position.
    - e. Secure with mounting bolts.
    - f. Locking device so that valve can be locked in any position with a wing nut.
  - 3. Stem and cover:
    - a. For submerged valves, provide extension stem as indicated on the Drawings.
  - 4. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
    - a. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
    - b. Rating: Rated for 10 amps, 120 volts alternating current.
    - c. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.
- B. Stem covers:
  - 1. Aluminum pipe:
    - a. Threaded cap on top.
    - b. Bolted aluminum flange on bottom.
    - c. Slots cut 1- by 12-inch at 18 inches on center in front and back of pipe.
    - d. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
  - 2. Ultraviolet light resistant, clear butyrate plastic or polycarbonate pipe:
    - a. Capped on the upper end.
    - b. Either threaded into the top of the gate operators or held in place by bolt-down aluminum brackets.
    - c. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.



3. Staff gauges:
  - a. Adhesive-backed mylar, suitable for outdoor service.
  - b. Calibrated in hundredths of feet.
  - c. Read the weir crest elevations directly.
  - d. Gauge range: 1.5 feet minimum.
  - e. Indicate the following elevations on each staff gauge:
    - 1) -0.75, -0.50, -0.25, 0.0, 0.25, 0.50, 0.75.
  - f. Supplement with a stem-mounted pointer or indicator that permits direct observation of the weir gate crest elevation.
  - g. Apply staff gauges to each stem cover after installation of the cover and after calibration and testing of the weir gates.
  - h. Set gauges precisely by a survey crew using instruments acceptable to the Engineer.
- C. Stem cover flanges, pipes and caps:
  1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
    - a. A 41 - Clear Anodic Coating.
    - b. C 22 - Medium Matte Finish.
- D. Gate stem covers: Concentric with stem.
- E. Position indicators:
  1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.
  2. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.
- F. Manual or power actuator size:
  1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.
- G. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.
- H. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.
- I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.
- J. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.
- K. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.



- L. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.
- M. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

## **2.02 HANDWHEEL ACTUATORS**

- A. Manufacturers: One of the following or equal:
  - 1. Rodney Hunt Co.
  - 2. Waterman Industries, Inc.
- B. Coating: Handwheel as specified in Section 09960 - High-Performance Coatings.
- C. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.
- D. Bearings above and below finished threaded bronze operating nut: Ball or roller.
- E. Wheel diameter: Minimum 24 inches.
- F. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.
- G. Pull to operate: Maximum 40 pounds pull at most adverse design condition.
- H. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.
- I. Grease fittings: Suitable for lubrication of bearings.

## **2.03 HAND-CRANKED GEARED ACTUATORS**

- A. Type: Single removable crank; fully enclosed.
- B. Mounting: Floor and bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.
- C. Operating nut: When scheduled for portable gate actuators.
- D. Geared lifts: 2-speed with minimum ratio of 4 to 1.
- E. Teeth on gears, spur pinions, bevel gears, and bevel pinions: Cut.
- F. Lift nuts: Cast manganese bronze.
- G. Exterior surfaces on cast-iron lift parts: Smooth.



- H. Bearings above and below flange on lift nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.
- I. Crank rotation indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.
- J. Hand cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
  - 1. Revolving brass sleeves.
  - 2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
  - 3. Cast manganese bronze lift nuts.
  - 4. Cast-iron lift parts with smooth exterior surfaces.
- K. Indicator: Dial position type mounted on gear actuator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

#### **2.04 FLOOR BOXES**

- A. Manufacturers: The following or equal:
  - 1. Waterman Industries, Inc.
- B. Floor boxes: Cast-iron; with:
  - 1. Counter type indicator.
  - 2. Hinged, lockable lid with directional arrow.
  - 3. 2-inch square AWWA operating nut.
  - 4. Packing gland providing drip-tight seal around valve shaft.

#### **2.05 FLOOR STAND**

- A. Manufacturers: One of the following or equal:
  - 1. Rodney Hunt Co.
  - 2. Waterman Industries, Inc.
- B. Floor stand assemblies: Heavy-duty cast-iron, suitable for mounting specified actuator.

#### **2.06 BENCH STANDS**

- A. Manufacturers: One of the following or equal:
  - 1. Rodney Hunt Co.
  - 2. Waterman Industries, Inc.
- B. Bench stands: Handwheel actuators or hand crank, geared actuators conforming to hand-cranked geared actuator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

#### **2.07 ACCESSORY EQUIPMENT**

- A. Wall brackets or haunches: As indicated on the Drawings.



- B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.
- C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.
- D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.
- E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.
- F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.
- G. Fasteners: Type 316 stainless steel.
- H. Anchor bolts: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry except that the material shall be Type 316 stainless steel.
- I. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.
- J. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.
- K. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install floor boxes in concrete floor with lid flush with floor.
- B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.
- C. Attach floor stand to structure with anchor bolts.
- D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.



### 3.02 SCHEDULES

- A. Geared actuators: Provide geared actuators for following valves:
  - 1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
  - 2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
  - 3. Plug valves 6 inches, nominal size, and larger.
- B. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.
- C. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION







## SECTION 13447

### ELECTRIC ACTUATORS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Electric motor-driven actuators for valves and gates except for specialty actuators specified with individual valves.

##### 1.02 REFERENCES

- A. American Water Works Association (AWWA):
  - 1. C504 - Standard for Rubber-Seated Butterfly Valves.
  - 2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.
- B. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

##### 1.03 DEFINITIONS

- A. NEMA:
  - 1. Type 4X enclosure in accordance with NEMA 250.
  - 2. Type 7 enclosure in accordance with NEMA 250.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures and Section 15050 - Common Work Results for Mechanical Equipment.
- B. Provide a complete list/schedule of all actuators being provided with their associated tag names as indicated on the design drawings and/or specifications, service process area and the size of the valve they are actuating.
- C. Product data:
  - 1. Electrical ratings:
    - a. Voltage and number of phases.
    - b. Starting and running current.
    - c. Voltage levels and source for control and status.
  - 2. Description of integral control interface.
  - 3. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
  - 4. Gear ratios for both manual and motorized actuation.
  - 5. Opening and closing directions.
  - 6. Allowable starts per hour.
  - 7. List of all included options and accessories.
  - 8. Full travel times.
  - 9. Gearbox data including gear ratio, and gearbox efficiency.



- D. Shop drawings:
  - 1. Wiring diagrams:
    - a. Include all options and expansion cards furnished with each actuator.
  - 2. Dimensioned drawings of each valve and actuator combination.
  - 3. Dimensioned drawings of each valve gearbox.
  - 4. Electric motor data.
- E. Calculations:
  - 1. Operating torque.
  - 2. Maximum torque calculations for seating and unseating.
  - 3. Maximum operating torque at starting and normal operation.
  - 4. Signed by Professional Engineer.
- F. Provide draft vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data:
  - 1. Include a list of all configurable parameters, and the final values for each.
  - 2. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.
- G. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
    - a. Affidavit in accordance with AWWA C542.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
- H. Project closeout documents:
  - 1. Provide final vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

## **1.05 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Manufacturers for lines 3 inch and smaller:
  - 1. The following or equal:
    - a. Rotork Controls Inc.:
      - 1) ROMpak (Quarter-Turn).
      - 2) CMA Range:
        - a) CMR - Multi-Turn.
        - b) CMQ - Quarter-Turn.
- B. Manufacturers for lines 4 inch and larger:
  - 1. One of following or equal:
    - a. Rotork Controls Inc. IQ3 Range:
      - 1) IQ for multi-turn applications.
      - 2) IQT for quarter-turn applications.



- b. Limitorque Corp.:
  - 1) Accutronix MX for multi-turn applications.
  - 2) Accutronix QX quarter-turn applications.
- c. Auma:
  - 1) SA (multi-turn) with Aumatic AC controls.
  - 2) SQ(quarter-turn) with Aumatic AC controls.

## **2.02 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER**

- A. Actuators for valves 3 inches and smaller:
  - 1. Provide actuators complete and operable with all components and accessories required for operation.
  - 2. Power supply:
    - a. Valve motion independent of power supply phase rotation.
    - b. 220/380/440 VAC 3-phase.
  - 3. Size actuator to move valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
    - a. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
  - 4. For all outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
  - 5. Control inputs:
    - a. Capable of using discrete 120 VAC.
    - b. Controls the valve when local-stop-remote is in REMOTE.
    - c. Material: Type 316 stainless steel.
    - d. Provide the following inputs at the actuator:
      - 1) OPEN.
      - 2) CLOSE.
  - 6. Status outputs:
    - a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
      - 1) FULLY CLOSED.
      - 2) FULLY OPEN.
      - 3) REMOTE.
    - b. All output contacts rated for 5 amps, 120 VAC.
  - 7. Analog input:
    - a. Provide a 4-20 milliamp analog input for analog modulating valves when indicated on the Drawings.
    - b. Modulate valve to maintain position based on analog input value.
    - c. Maximum input impedance 250 ohms.
  - 8. Analog output:
    - a. Provide an isolated 4-20 milliamp analog output when indicated on the Drawings.
  - 9. Materials:
    - a. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.
  - 10. Components:
    - a. Motors:
      - 1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.



- 2) Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
  - a) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
  - b) 60 starts per hour minimum for open/close service.
- b. Enclosures:
  - 1) Actuator housing ratings as indicated in the Motorized Actuator Schedule.
  - 2) Stainless steel external fasteners.
- c. Manual actuation:
  - 1) Hand wheel for manual operation.
- d. Gearing: Self-locking, high-alloy steel gears.

## **2.03 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER**

- A. Provide actuators complete and operable with all components and accessories required for operation.
- B. Power supply:
  1. Voltage and phases as indicated in the Motorized Actuator Schedule.
  2. Valve or gate motion independent of power supply phase rotation.
  3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
  4. The actuators shall incorporate all major components such as the motor, starter, local controls, terminals, etc. housed within a self-contained, sealed enclosure.
- C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
  1. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
  2. Size actuators so that gear boxes are not required where possible.
- D. Control interface:
  1. Configuration:
    - a. Provide a non-intrusive, non-contacting interface for configuring all input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
      - 1) Configurable from a handheld configuring tool or input devices on the actuator.
  2. Local interface, integral to actuator:
    - a. Non-intrusive, non-contacting selector switches:
      - 1) LOCAL-STOP-REMOTE:
        - a) Motor actuator operation is prevented with the switch in STOP.
      - 2) OPEN-CLOSE:
        - a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
        - b) Spring return to center.



- c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
  - b. Local display:
    - 1) Valve fully open and fully closed indicators.
    - 2) Numerical display showing actual valve or gate position in percent of travel.
- 3. Remote control station - (VCP):
  - a. Provide remote control stations for all actuators located more than 5 feet above finished floor/grade or where indicated on the Drawings or Schedule.
    - 1) NEMA rating as listed in the Valve and Gate Schedule.
      - a) Where the rating is not listed, use NEMA Type 4X enclosures for non-hazardous areas, and explosion-proof (XP) Class I Division 1 for hazardous areas.
      - b) All pilot devices shall 30 millimeters, and pilot lights shall be illuminated by LEDs.
    - 2) LOCAL-STOP-REMOTE selector switch.
    - 3) LOCAL mode control devices:
      - a) Operate valve when LOCAL-STOP-REMOTE integral to actuator is in REMOTE and LOCAL-STOP-REMOTE on remote control station is in LOCAL.
      - b) OPEN-STOP-CLOSE maintained switch or OPEN, STOP, and CLOSE pushbuttons where Maintained operation is indicated in the Valve and Gate Schedule.
      - c) OPEN-CLOSE spring-return switch or OPEN and CLOSE pushbuttons where momentary operation is indicated in the Valve and Gate Schedule.
    - 4) Pilots lights to indicate valve position:
      - a) Fully open.
      - b) Fully closed.
- 4. Rotork's Remote Hand Station:
  - a. Pole mounted.
  - b. Configuration: Bluetooth configuration tool.
  - c. Power: Via attached actuator (24 VDC output).
  - d. Enclosure:
    - 1) IP68.
  - e. Double sealed.
- 5. Control inputs:
  - a. Capable of using 120 VAC or 24 VDC inputs.
  - b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
  - c. Isolated inputs capable of operating from external control voltage source or internal power supply:
    - 1) Furnish 120 VAC or 24 VDC control power supplies within the actuator.
  - d. Provide the following inputs:
    - 1) OPEN.
    - 2) CLOSE.
    - 3) STOP.
  - e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).



6. Status outputs:
  - a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
  - b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
    - 1) Fully closed.
    - 2) Fully open.
    - 3) LOCAL-STOP-REMOTE in REMOTE position.
  - c. All output contacts rated for 5 amps, 120 VAC, and 24 VDC.
- E. Features:
  1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
  2. Data logging:
    - a. Store diagnostic data and reference data.
    - b. Time-stamped historical operating data, including number of operations and most recent operations.
    - c. Starting torque, maximum running torque, and end of travel torque.
      - 1) Store reference data (recorded during commissioning) and data from last operation.
  3. Provide display of logged data on the actuator, or provisions to download to a personal computer.
- F. Materials:
  1. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.
- G. Components:
  1. Motors:
  2. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
  3. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
    - a. Design requirements for rubber-seated AWWA butterfly valves:
      - 1) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542.
        - a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
        - b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
    - b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
      - 1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C542.
      - 2) Design for the maximum torque and thrust running load over the full cycle.



- 3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
  4. Capable of being removed and replaced without draining the actuator gear case.
  5. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
  6. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
    - a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
    - b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
  7. Provide the following motor protection features:
    - a. Jammed valve (no valve motion detected through a time delay).
    - b. High motor temperature (sensed by an embedded thermostats).
    - c. High torque.
    - d. Single phasing protection.
- H. Enclosures:
1. Actuator housing ratings as indicated in the Motorized Actuator Schedule.
  2. Stainless steel external fasteners.
  3. Provide o-ring seals for each of the following areas:
    - a. Between the terminal compartment and the internal electrical elements.
    - b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
  4. Provide the following minimum enclosure ratings:
    - a. NEMA Type 4X enclosure for general applications.
    - b. NEMA Type 7 enclosure for Class 1 applications.
- I. Position sensing:
1. Electronic and adjustable using a solid-state encoder wheel.
    - a. Mechanical limit switches and potentiometers are not acceptable.
  2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
  3. Valve range and position switch outputs field adjustable.
- J. Torque sensing:
1. Torque shutdown setting: 40 percent to 100 percent rated torque:
    - a. Adjustable in 1 percent increments.
  2. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
  3. Electrical or electronic torque sensing:
    - a. Extrapolating torque from mechanically measured motor speed is not acceptable due to response time.
  4. Independent of variations in frequency, voltage, or temperature.
  5. The actuator shall store actual operational torque curves for retrieval by plant maintenance staff.





6. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
  7. Provide visible verification of torque switch status without any housing disassembly.
- K. Manual actuators:
1. Hand wheel for manual operation.
    - a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
    - b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
      - 1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
      - 2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
  2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.
- L. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
1. Accurately cut to ensure minimum backlash.
- M. Bearings:
1. Anti-friction bearing with caged balls or rollers throughout.
  2. Sealed-for-life type thrust bearings housed in a separate thrust base.
- N. Drive bushing:
1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
  2. Positioned in a detachable base of the actuator.
- O. Lubrication:
1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
  2. Actuators requiring special or exotic lubricants are not acceptable.

## **2.04 ACCESSORIES**

- A. Software:
1. Furnish PC-based diagnostic and configuration software to display diagnostic data.
  2. Provide software communications to the valve actuator using Bluetooth wireless or IrDA infrared communications.
    - a. Provide all accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.
    - b. Where infrared communications are used, furnish an IrDA to USB adapter with a mounting device to secure the infrared element to the valve actuator IrDA port:
      - 1) Provide with a minimum cable length of 3 feet, capable of being extended with a standard USB extension cable.





- B. Termination module cover:
  - 1. Provide sunshades for all outdoor installations of remote control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

## **2.05 SPARE PARTS AND SPECIAL TOOLS**

- A. As specified in Section 01600 - Product Requirements.
- B. Spare parts:
  - 1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
    - a. Stem nut.
    - b. Worm shaft subassembly.
    - c. Drive sleeve subassembly.
    - d. Complete actuator seal kit.
    - e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
    - f. Encoder.
    - g. Control module.
  - 2. Provide 1 spare motor for each size motor furnished.
- C. Setting tool:
  - 1. If required for setting or configuring the actuator, provide a handheld setting tool. Provide a handheld setting tool capable of non-intrusive calibration and interrogation of the actuator.
    - a. Furnish 1 setting tool for every 10 actuators.
    - b. Capable of communicating with PC-based configuration software, and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator.
    - c. Actuator configurations:
      - 1) Capable of storing up to 10 different configurations.
    - d. Diagnostic data:
      - 1) Capable of storing 4 complete sets of diagnostic data.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.
- B. Position visual indicators so that they are most easily visible.

### **3.02 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning, Section 15958 - Mechanical Equipment Testing, and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Source Testing:



- 1) Proof-of-Design and Performance Test Reports in accordance with AWWA C542.
- b. Manufacturer's Certificate of Installation and Functionality Compliance.
2. Manufacturer's Representative on-site requirements:
  - a. Installation: 2 trips, 2-day minimum each.
  - b. Functional testing: 2 trips, 2-day minimum each.
3. Training:
  - a. Maintenance: 4 hours per session, 2 sessions.
  - b. Operation: 2 hours per session, 2 sessions.
- C. Source testing:
  1. Design and Performance Test Reports in accordance with AWWA C542.
  2. Test each actuator with a simulated load.
    - a. Simulate a typical valve load.
  3. Electrical Instrumentation and Controls:
    - a. Test witnessing: not witnessed.
    - b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.
- D. Functional testing:
  1. Installed actuator:
    - a. Test witnessing: Witnessed.
    - b. Conduct Level 2 General Equipment Performance Tests.
    - c. Conduct Level 2 Vibration Tests.
    - d. Conduct Level 2 Noise Tests.
  2. Electrical Instrumentation and Controls:
    - a. Test witnessing: Witnessed.
    - b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.03 MOTORIZED ACTUATOR SCHEDULE**

- A. Provide all actuators indicated on the Drawings:
  1. Major process actuators are listed in the Intelligent Actuator Schedule in this Section.
  2. The Motorized Actuator Schedule does not include all number and types of actuators required for the Project.
- B. Abbreviations relating to type:
  1. BFV = Butterfly Valve.
  2. BV = Ball Valve.
  3. PV = Plug Valve.
  4. SG = Slide Gate.
  5. TWV = Three Way Valve
- C. Abbreviations relating to actuator type:
  1. O/C = Open and Close Service.
  2. MOD = Modulating Service.
- D. Abbreviations relating to controls:
  1. PA = Profibus PA.
  2. DP = Profibus DP.
  3. DN = DeviceNet.



4. FF = Foundation Fieldbus H1.
5. MB = Modbus RTU (RS-485).
6. NET = Manufacturer's proprietary network.
7. A = Analog (4-20 mA) control, modulating duty.
8. D = Discrete control, modulating duty.
9. D-O/C = Discrete Open/Close.
10. EIP = EtherNet/IP



INTELLIGENT ACTUATOR SCHEDULE										
Item	Reference DWG	Tag Number	Type	Size	Actuator Type	NEMA Rating	Voltage/ Phase/ Hz	Notes	Open Time	Controls
FOG Receiving Facility	20M02	FCV- 211	BV	1 HP	O/C	4X	480/3/60		30 s	EIP, D- O/C
Digester FOG Feed No.1	10M05	FCV- 212	PV	1 HP	O/C	7	480/3/60		30 s	EIP, D- O/C
Digester FOG Feed No.2	10M05	FVC- 213	PV	1 HP	O/C	7	480/3/60		30 s	EIP, D- O/C
Hot Water System	10M05	FCV- 214	TWV	1 HP	MOD	7	480/3/60		30 s	EIP, A



## SECTION 15050

### COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Basic design and performance requirements for building mechanical equipment and process mechanical equipment.

##### 1.02 REFERENCES

- A. American Gear Manufacturer's Association (AGMA) Standards:
  - 1. 6001-E08 - Design and Selection of Components for Enclosed Gear Drives.
- B. American Bearing Manufacturers Association (ABMA) Standards:
  - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
  - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. American Petroleum Institute (API):
  - 1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.
- D. ASTM International (ASTM):
  - 1. A36 - Standard Specification for Carbon Structural Steel.
  - 2. A48 - Standard Specification for Gray Iron Castings.
  - 3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
  - 4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
  - 7. A536 - Standard Specification for Ductile Iron Castings.
  - 8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  - 9. B61 - Standard Specification for Steam or Valve Bronze Castings.
  - 10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
  - 11. B505 - Standard Specification for Copper Alloy Continuous Castings.
  - 12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
  - 13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
  - 14. F594 - Standard Specification for Stainless Steel Nuts.
- E. Hydraulic Institute (HI).
- F. Occupational Safety and Health Administration (OSHA).
- G. Unified Numbering System (UNS).



03

## DEFINITIONS

- A. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.
- B. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.
- C. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.
- D. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.
- E. Rotational speed: Same as rotational frequency.
- F. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.
- G. Critical speed: Same as critical frequency.
- H. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.
- I. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

## 1.04 DESIGN REQUIREMENTS

- A. General:
  - 1. Product requirements as specified in Section 01600 - Product Requirements.
  - 2. Project conditions as specified in Section 01610 - Project Design Criteria.
  - 3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
  - 4. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
  - 5. Vibration considerations:
    - a. Resonant frequency:
      - 1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
      - 2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
    - b. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958 - Mechanical Equipment Testing.
  - 6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.



- B. Power transmission systems:
1. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a service factor of 1.5 or greater in accordance with manufacturer recommendations:
    - a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
    - b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.
- C. Equipment mounting and anchoring:
1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames.
    - a. Utilize continuous welds to seal seams and contact edges between steel members.
    - b. Grind welds smooth.
  2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
  3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
  4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01612 - Seismic Design Criteria, and other loads as required for proper operation of equipment.
    - a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
      - 1) The operating weight and location of the centroid of mass for the equipment.
      - 2) Forces and overturning moments.
      - 3) Shear and tension forces in equipment anchorages, supports, and connections.
      - 4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
  5. Anchorage of equipment to concrete or masonry:
    - a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
    - b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    - c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
      - 1) Adjust bolts to final location and secure the sleeve.
  6. Anchorage of equipment to metal supports:
    - a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
  7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.



## 05 SUBMITTALS

- A. As specified in Section 01600 - Product Requirements.
- B. Product data:
  - 1. For each item of equipment:
    - a. Design features.
    - b. Load capacities.
    - c. Efficiency ratings.
    - d. Material designations by UNS alloy number or ASTM Specification and Grade.
    - e. Data needed to verify compliance with the Specifications.
    - f. Catalog data.
    - g. Nameplate data.
    - h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
  - 2. Gear reduction units:
    - a. Engineering information in accordance with applicable AGMA standards.
    - b. Gear mesh frequencies.
- C. Shop drawings:
  - 1. Drawings for equipment:
    - a. Drawings that include cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
  - 2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
  - 3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
  - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
  - 5. Recommended or normal operating parameters such as temperatures and pressures.
  - 6. Alarm and shutdown setpoints for all controls furnished.
- D. Calculations:
  - 1. Structural:
    - a. Substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design requirements specified and seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
  - 2. Mechanical:
    - a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
    - b. Substantiate that operating rotational frequencies meet the requirements of this Section.





- c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
  - 1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
  - 2) Results of analysis including first and second critical frequencies of system components and complete system.
- d. Calculations shall be signed and stamped by a licensed engineer.
- 3. Drinking water:
  - a. If applicable, conform to the requirements of Section 01600 - Product Requirements for materials in contact with drinking water.
- E. Operation and maintenance manuals:
  - 1. As specified in Section 01782 - Operating and Maintenance Data.
  - 2. Equipment with bearings:
    - a. Include manufacturer and model number of every bearing.
    - b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
- F. Commissioning submittals: As specified in Section 01756 - Commissioning.
- G. Project closeout documents: As specified in Section 01770 - Closeout Procedures.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.
- B. Ferrous materials:
  - 1. Steel for members used in fabrication of assemblies: ASTM A36.
  - 2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
  - 3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
  - 4. Galvanized steel sheet: ASTM A653, minimum 0.0635-inch (16-gauge).
  - 5. Expanded metal: ASTM A36, 13-gauge, 1/2-inch flat pattern expanded metal.
  - 6. Stainless steel:
    - a. As specified in Section 05120 - Structural Steel.
    - b. In contact or within 36 inches of water: Type 316 or 316L.
    - c. In sea air environment: Type 316 or 316L.
    - d. Other locations: Type 304 or 304L.
    - e. Source cleaning and passivation as specified in Section 05120 - Structural Steel.
- C. Non-ferrous materials:
  - 1. Bronze in contact with drinking water: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C89833, C89520, or C92200 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.



2. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, C89520, C92200, or C93700 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
  3. Aluminum: As specified in Section 05140 - Structural Aluminum.
- D. Dielectric materials for separation of dissimilar metals:
1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.
- E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03600 - Grouting.

## **2.02 ANCHORS AND FASTENERS**

- A. Mechanical anchoring to concrete and masonry:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry:
    - a. Type 316 stainless steel.
  2. Design as specified in Section 01612 - Seismic Design Criteria.
- B. High-strength fasteners:
1. As specified in Section 05120 - Structural Steel.
- C. Flange bolts:
1. As specified in Section 15052 - Common Work Results for General Piping.
- D. Mechanical assembly fasteners:
1. Stainless steel:
    - a. High-temperature service or high-pressure service:
      - 1) Bolts: ASTM A193, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
      - 2) Nuts: ASTM A194, Grade 8, heavy hex.
      - 3) Washers: Alloy group matching bolts and nuts.
    - b. Low-temperature service:
      - 1) Bolts: ASTM A320, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
      - 2) Nuts: ASTM A194, Grade 8 (Type 304) or Grade B8M (Type 316), heavy hex.
      - 3) Washers: Alloy group matching bolts and nuts.
    - c. General service:
      - 1) Bolts: ASTM F593, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
      - 2) Nuts: ASTM F594, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
      - 3) Washers: Alloy group matching bolts and nuts.



## 2.03 SHAFT COUPLINGS

- A. General:
  - 1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
  - 2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.
- B. Shaft couplings for close-coupled electric-motor-driven equipment:
  - 1. Use for:
    - a. Equipment 1/2 horsepower or larger.
    - b. Reversing equipment.
    - c. Equipment subject to sudden torque reversals or shock loading:
    - d. Examples:
      - 1) Reciprocating pumps, blowers, and compressors.
      - 2) Conveyor belts.
  - 2. Manufacturers: One of the following or equal:
    - a. Lovejoy.
    - b. T.B. Woods.
  - 3. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
  - 4. Manufacture flexible component of coupling from synthetic rubber or urethane.
  - 5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
  - 6. Do not allow metal-to-metal contact between driver and driven equipment.
- C. Shaft couplings for direct-connected electric-motor-driven equipment:
  - 1. Use for 1/2 horsepower or larger and subject to normal torque, non-reversing applications.
  - 2. Manufacturers: One of the following or equal:
    - a. Rexnord.
    - b. T.B. Woods.
  - 3. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
  - 4. Provide flexible connecting element of rubber and reinforcement fibers.
  - 5. Provide service factor of 2.0.
  - 6. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.
- D. Spacer couplings: Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.
- E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer:
  - 1. Includes any engine-driven equipment.

## 2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

- A. General:
  - 1. Unless otherwise noted in the equipment section, provide cartridge-type, double mechanical shaft seals for pumps.
  - 2. Provide a stuffing box large enough for a double mechanical seal.



3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
  4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
  5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
  6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
  7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
    - a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
    - b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
    - c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
    - d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water).
    - e. Double seal applications: Plan 54 (External seal water).
- B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
1. Wastewater, water, and sludge applications:
    - a. Asbestos free.
    - b. PTFE (Teflon) free.
    - c. Braided graphite.
    - d. Manufacturers: One of the following or equal:
      - 1) Chesterton, 1400.
      - 2) John Crane, equivalent product.
  2. Drinking water service:
    - a. Asbestos free.
    - b. Material: Braided PTFE (Teflon).
    - c. Manufacturers: One of the following or equal:
      - 1) Chesterton, 1725.
      - 2) John Crane, equivalent product.
- C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
1. Provide seal types meeting the following requirements:
    - a. Balanced hydraulically.
    - b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
    - c. O-ring: Viton 747.
    - d. Gland: Type 316L stainless steel.
    - e. Set screws: Type 316L stainless steel.
    - f. Faces: Reaction bonded, silicon carbide.
    - g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.



2. Cartridge-type single mechanical:
  - a. Manufacturers: One of the following or equal:
    - 1) Chesterton, S10.
    - 2) John Crane, 5610 Series.
3. Cartridge-type double mechanical: Manufacturers:
  - a. One of the following or equal:
    - 1) Chesterton, S20.
    - 2) John Crane, 5620 Series.
4. Split-face single mechanical: Manufacturers:
  - a. One of the following or equal:
    - 1) Chesterton, 442.
    - 2) John Crane, 3740.
5. Cartridge-type flushless mechanical:
  - a. Manufacturers: One of the following or equal:
    - 1) Chesterton, 156.
    - 2) John Crane, 5870.

## **2.05 GEAR REDUCTION UNITS**

- A. Type: Helical or herringbone, unless otherwise specified.
- B. Design:
  1. Made of alloys treated for hardness and for severe service.
  2. AGMA Class II service:
    - a. Use more severe service condition when such is recommended by unit's manufacturer.
  3. Cast-iron housing with gears running in oil.
  4. Anti-friction bearings.
  5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.
  6. Manufactured in accordance with applicable AGMA standards.
- C. Planetary gear units are not to be used.

## **2.06 BELT DRIVES**

- A. Sheaves:
  1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
  2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
  3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
  4. Key bushings to drive shaft.
- B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
  1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
    - a. Where 2 or more belts are involved, furnish matched sets.
    - b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
    - c. Package in boxes labeled with identification of contents.



- C. Manufacturers: One of the following or equal:
  - 1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
  - 2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

## **2.07 BEARINGS**

- A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
- B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
  - 1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610 - Project Design Criteria.
  - 2. Provide an external oil cooler when required to satisfy the specified operating conditions:
    - a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
    - b. Equip oil cooler with a filler pipe and external level gauge.
- C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
  - 1. Lubrication lines and fittings:
    - a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
    - b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
    - c. Use standard hydraulic-type grease supply fittings:
      - 1) Manufacturers: One of the following or equal:
        - a) Alemite.
        - b) Zerk.
- D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

## **2.08 MOTORS**

- A. As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.

## **2.09 GEAR MOTORS**

- A. Motors as specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.
- B. Helical gearing for parallel shaft drives and worm gearing for right-angle drives.
- C. Manufactures: One of the following or equal:
  - 1. Baldor Electric Company.
  - 2. Bodine Electric Company.



## **2.10 VENDOR CONTROL PANELS**

- A. As specified in Section 17710 – Control Systems: Panels, Enclosures, and Panel Components.

## **2.11 EQUIPMENT SUPPORT FRAMES**

- A. Bolt holes shall not exceed bolt diameter by more than 25 percent, up to a limiting maximum diameter oversize of 1/4-inch.

## **2.12 PIPING AND VALVES**

- A. Piping as specified in Section 15052 - Common Work Results for General Piping.
- B. Valves as specified in Section 15110 - Common Work Results for Valves.

## **2.13 SAFETY EQUIPMENT**

- A. Safety guards:
  - 1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
  - 2. Requirements:
    - a. Allow visual inspection of moving parts without removal.
    - b. Allow access to lubrication fittings.
    - c. Prevent entrance of rain or dripping water for outdoor locations.
    - d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
  - 3. Materials:
    - a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
    - b. Fasteners: Type 304 stainless steel.
- B. Insulation:
  - 1. Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level.
  - 2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.
  - 3. Insulation Type 3 and cover Type 5 as specified in Section 15082 - Piping Insulation.
- C. Warning signs:
  - 1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
  - 2. Material, sign size, and text: As specified in Section 10400 - Signage.
  - 3. Mount warning signs with stainless steel fasteners at equipment.

## **2.14 SPRING VIBRATION ISOLATORS**

- A. Design requirements:
  - 1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.





2. Use steel coil springs.
  3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
- B. Performance requirements: Minimum spring deflection of 1-inch under static load and capable of limiting transmissibility to 10 percent maximum at design operating load.
- C. Manufacturers: One of the following or equal:
1. California Dynamics Corporation, Type RJSD.
  2. Mason Industries, equivalent product.
- D. Materials:
1. Fabricate isolators using welded-steel or shatterproof ductile iron in accordance with ASTM A536 Grade CS-45-12.
  2. Spring steel: ASTM A125.

## **2.15 NAMEPLATES**

- A. Fastened to equipment at factory in an accessible and visible location.
- B. Stainless steel sheet engraved or stamped with text, holes drilled or punched for fasteners.
- C. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.
- D. Text:
1. Manufacturer's name, equipment model number and serial number, motor horsepower when appropriate, and identification tag number.
  2. Indicate the following additional information as applicable:
    - a. Maximum and normal rotating speed.
    - b. Service class per applicable standards.
  3. Include for pumps:
    - a. Rated total dynamic head in feet of fluid.
    - b. Rated flow in gallons per minute.
    - c. Impeller, gear, screw, diaphragm, or piston size.
  4. Include for gear reduction units:
    - a. AGMA class of service.
    - b. Service factor.
    - c. Input and output speeds.

## **2.16 SHOP FINISHES**

- A. Provide appropriate factory coatings as specified in Section 09960 - High-Performance Coatings.
1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

## **2.17 SPECIAL TOOLS**

- A. Supply 1 set of special tools as specified in Section 01600 - Product Requirements.





## **2.18 SOURCE TESTING**

- A. Testing requirements unless specified otherwise in the individual equipment specifications:
  - 1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 15958 - Mechanical Equipment Testing.
  - 2. Motors: As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.
  - 3. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

## **2.19 SHIPPING**

- A. As specified in Section 01600 - Product Requirements.
- B. Prior to shipment of equipment:
  - 1. Bearings (and similar items):
    - a. Pack separately or provide other protection during transport.
    - b. Greased and lubricated.
  - 2. Gear boxes:
    - a. Oil filled or sprayed with rust preventive protective coating.
  - 3. Fasteners:
    - a. Inspect for proper torques and tightness.

# **PART 3 EXECUTION**

## **3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION**

- A. As specified in Section 01600 - Product Requirements.
- B. Inspect fasteners for proper torques and tightness.
- C. Storage:
  - 1. Bearings:
    - a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
  - 2. Gear boxes:
    - a. Inspect to verify integrity of protection from rust.
- D. Protection:
  - 1. Equipment Log shall include description of rotation performed as part of maintenance activities.

## **3.02 INSTALLATION**

- A. Field measurements:
  - 1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
  - 2. Ensure equipment and ancillary appurtenances fit within available space.



- B. Sequencing and scheduling:
  - 1. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place.
  - 2. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
- C. Metal work embedded in concrete:
  - 1. Accurately place and hold in correct position while concrete is being placed.
  - 2. Clean surface of metal in contact with concrete immediately before concrete is placed.
- D. Concrete surfaces designated to receive non-shrink grout:
  - 1. Heavy sandblast concrete surface in contact with non-shrink grout.
  - 2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
  - 3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.
- E. Install equipment in accordance with manufacturer's installation instructions and recommendations.
- F. Lubrication lines and fittings:
  - 1. Support and protect lines from source to point of use.
  - 2. Fittings:
    - a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
    - b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
    - c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.
- G. Alignment of drivers and equipment:
  - 1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
  - 2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
    - a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
    - b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
  - 3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.



4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
  5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
    - a. Allow minimum 48 hours for grout to harden.
    - b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
    - c. Correct alignment as required.
  6. After functional testing is complete, dowel motor or drivers and driven equipment:
    - a. Comply with manufacturer's instructions.
- H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03600 - Grouting.
    - a. Non-shrink epoxy grout required only when indicated on the Drawings.
  2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
  3. Install grout only after:
    - a. Equipment is leveled and in proper alignment.
    - b. Piping connections are complete and in alignment with no strain transmitted to equipment.
  4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
  5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
    - a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
    - b. Use suitable number and size of jack screws.
    - c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
    - d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
    - e. Place and cure grout as specified in Section 03600 - Grouting.
    - f. After grout is cured, remove jack screws and material used to prevent bonding to grout.
      - 1) Provide jack screws to Owner for future use.
    - g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
    - h. Fill holes where jack screws have been removed with grout.
    - i. Cure as specified in Section 03600 - Grouting.
  6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
    - a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
    - b. Place and cure grout as specified in Section 03600 - Grouting.
    - c. Remove wedges or shims.
    - d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
    - e. Fill voids where wedges and shims have been removed with grout.



- f. Cure as specified in Section 03600 - Grouting.
  - 7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
    - a. Metal in contact with grout: Grit blast to white metal finish.
    - b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint, and other material that will reduce bond.
  - 8. Preparation of concrete equipment foundation for grouting:
    - a. Rough concrete surfaces in contact with grout.
    - b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
    - c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
    - d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.
  - 9. Forms and header boxes:
    - a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
    - b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
    - c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
  - 10. Grout placement requirements:
    - a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising:
      - 1) Conform to grout manufacturer's temperature requirements.
    - b. Pour grout using header box.
    - c. Keep level of grout in header box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment.
    - d. Grout shall flow continuously from header box to other side of forms without trapping air or forming voids.
    - e. Vibrate, rod, or chain grout to facilitate grout flow, consolidate grout, and remove entrapped air.
    - f. After grout sets, remove forms and trim grout at 45-degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
    - g. Cure as specified in Section 03600 - Grouting.
  - I. Field welding:
    - 1. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
    - 2. Shielded arc welding.
  - J. Field finishes:
    - 1. Protect motors.
    - 2. Clean equipment.
    - 3. Apply primer and coating systems as specified in Section 09960 - High-Performance Coatings requirements.
  - K. Special techniques:
    - 1. Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.



- L. Tolerances:
  - 1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.
- M. Warning signs:
  - 1. Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

### **3.03 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
  - 1. Mechanical equipment: Level 1 tests as specified in Section 15958 - Mechanical Equipment Testing.
  - 2. Motors: As specified in Sections 16222 - Low Voltage Motors Up to 500 Horsepower and 16950 - Field Electrical Acceptance Tests.
  - 3. Vendor control panels: As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION





## SECTION 15052

### COMMON WORK RESULTS FOR GENERAL PIPING - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Basic materials and methods for metallic and plastic piping systems.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
  - 2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.
- B. American Water Work Association (AWWA):
  - 1. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.
- C. ASTM International (ASTM):
  - 1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 2. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 3. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
  - 4. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  - 5. F37 - Standard Test Methods for Sealability of Gasket Materials.
  - 6. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
- D. NSF International (NSF).

##### 1.03 DEFINITIONS

- A. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
- B. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
- C. Underground pipes: Buried pipes - see A. above.
- D. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
- E. Wet wall: A wall with water on at least 1 side.



## **ART 2 PRODUCTS**

### **2.01 GENERAL**

- A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

### **2.02 ESCUTCHEONS**

- A. Material: Chrome-plated steel plate.
- B. Manufacturers: One of the following or equal:
  - 1. Dearborn Brass Co., Model Number 5358.
  - 2. Keeney Manufacturing Co., Model Number 102 or Number 105.

### **2.03 LINK TYPE SEALS**

- A. Characteristics:
  - 1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
  - 2. Links to form a continuous rubber belt around the pipe.
  - 3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
  - 4. Hardware to be Type 316 stainless steel.
    - a. Provide anti-galling lubricant for threads.
- B. One of the following or equal:
  - 1. Link-Seal.
  - 2. Pipe Linx.

### **2.04 FLANGE BOLTS AND NUTS**

- A. General:
  - 1. Washer:
    - a. Provide a washer for each nut.
    - b. Washer shall be of the same material as the nut.
  - 2. Nuts: Heavy hex-head.
  - 3. Cut and finish flange bolts to project a maximum of 1/4-inch beyond outside face of nut after assembly.
  - 4. Tap holes for cap screws or stud bolts when used.
  - 5. Lubricant for stainless steel bolts and nuts:
    - a. Chloride-free.
    - b. Manufacturers: One of the following or equal:
      - 1) Huskey FG-1800 Anti-Seize.
      - 2) Weicon Anti-Seize High-Tech.
- B. For ductile iron pipe:
  - 1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
    - a. Bolts: ASTM A307, Grade B.
    - b. Nuts: ASTM A563, Grade A.
    - c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.





2. On exposed pipes with pressures greater than 150 psig:
    - a. Bolts: ASTM A193, Grade B.
    - b. Nuts: ASTM A194, Grade 2H.
    - c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
  3. On underwater pipes and pipes adjacent to wet walls:
    - a. Bolts: ASTM A193, Grade B8M.
    - b. Nuts: ASTM A194, Grade 8M.
- C. Plastic pipe:
1. On exposed pipes:
    - a. Bolts: ASTM A307, Grade B.
    - b. Nuts: ASTM A563, Grade A.
    - c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
  2. On underwater pipes and pipes adjacent to wet walls:
    - a. Bolts: ASTM A193, Grade B8M.
    - b. Nuts: ASTM A194, Grade 8M.
- D. Steel pipe:
1. On exposed pipes:
    - a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
      - 1) Bolts: ASTM A307, Grade B.
      - 2) Nuts: ASTM A563, Grade A.
      - 3) Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
    - b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
      - 1) Bolts: ASTM A193, Grade B7.
      - 2) Nuts: ASTM A194, Grade 2H.
  2. On underwater pipes and pipes adjacent to wet walls:
    - a. Bolts: ASTM A193, Grade B8M.
    - b. Nuts: ASTM A194, Grade 8M.

## 2.05 GASKETS

- A. General.
1. Gaskets shall be suitable for the specific fluids, pressure, and temperature conditions.
  2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.
- B. Gaskets for flanged joints in ductile iron for fats, oils, and grease service:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and continuous contact with fats, oils, and grease service.
  2. Gasket material:
    - a. Buna-N with minimum Shore A hardness value of 60.
    - b. Reinforcement: Cloth or synthetic fiber.
    - c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe
  3. Manufacturers: One of the following or equal:
    - a. Pipe less than 48 inches in diameter:
      - 1) Garlock, IFG Style 5500.
      - 2) John Crane, similar product.



- C. Gaskets for flanged joints in ductile iron and steel piping for sewage service:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
  2. Gasket material:
    - a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
    - b. Reinforcement: Cloth or synthetic fiber.
    - c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
  3. Manufacturers: One of the following or equal:
    - a. Pipe less than 48 inches in diameter:
      - 1) Garlock, Style 7797.
      - 2) John Crane, similar product.
    - b. Pipe 48 inches in diameter and larger:
      - 1) Garlock, Style 3760.
      - 2) John Crane, similar product.
- D. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
  2. Material:
    - a. Chemical systems: 0.125-inch thick Viton rubber.
    - b. Sewer and water: 0.125-inch thick SBR.
  3. Manufacturers: One of the following or equal:
    - a. Garlock.
    - b. John Crane, similar product.
- E. Gaskets for flanged joints in gas or liquefied petroleum gas piping:
1. Digester gas in stainless steel, or black steel piping: Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 200 degrees Fahrenheit, and digester gas and mild acid concentrations.
  2. Chlorine gas application in black steel piping: Suitable for pressures equal to or less than 300 pounds per square inch gauge, temperatures equal to or less than 100 degrees Fahrenheit, and chlorine gas application.
  3. Liquefied petroleum, propane, and natural gas applications in black steel piping: Suitable for pressures equal to and less than 250 pounds per square inch gauge, temperatures equal to and less than 100 degrees Fahrenheit, and liquefied petroleum gas, propane gas, and natural gas application.
  4. Material:
    - a. Microcellular Teflon outer layers with rigid center layer.
    - b. Sealability in accordance with ASTM F37, less than 0.55 millimeters per hour leakage of iso-octane at 1,000 pounds per square inch gasket load and 9.8 pounds per square inch fluid pressure.
  5. Manufacturers: One of the following or equal:
    - a. Garlock, Style 3545.
    - b. John Crane, similar product.



- F. Gaskets for flanged joints in low pressure air piping:
  - 1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 300 degrees Fahrenheit, and compressed air service.
  - 2. Material: EPDM elastomer, 1/8-inch thick, 60 Shore hardness, smooth surface.
  - 3. Manufacturers: One of the following or equal:
    - a. Garlock, Style 8314.
    - b. John Crane, similar product.
- G. Gaskets for flanged joints in ductile iron or steel water piping:
  - 1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
  - 2. Material:
    - a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
  - 3. Manufacturers: One of the following or equal:
    - a. Garlock, Bluegard 3300.
    - b. John Crane, similar product.
- H. Gaskets for flanged joints in ductile iron or steel drinking water piping meeting NSF requirements:
  - 1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 200 degrees Fahrenheit.
  - 2. Material:
    - a. EPDM material with 80 Shore A durometer rating.
  - 3. Manufacturers: One of the following or equal:
    - a. Garlock, 98206.
    - b. John Crane, similar product.
- I. Gaskets for grooved joints in ductile iron:
  - 1. Material to be used for following services unless otherwise specified:
    - a. FlushSeal® type or equal
      - 1) For liquid service:
        - a) Nitrile: Grade S; for temperatures to 180 degrees Fahrenheit.
      - 2) For FOG service:
        - a) Buna-N with minimum Shore A hardness value of 60.
      - 3) For hot water service: EPDM.
      - 4) For air service: Fluoroelastomer.
- J. Gaskets for grooved joints in steel piping:
  - 1. Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
    - a. Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
    - b. Gaskets for use with cement-mortar lined steel piping for temperatures less than 180 degrees Fahrenheit shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.



## 06 REPAIR BANDS

- A. Design requirements:
  - 1. In accordance with AWWA C230.
- B. Materials:
  - 1. Shells: Type 304 stainless steel.
  - 2. Lugs: Removable epoxy coated ductile iron in accordance with ASTM A536.
  - 3. Bolts and nuts: 304 Stainless Steel with fluoropolymer coated nuts.
  - 4. Gaskets: Compounded for water and sewer service.
- C. Manufacturers: One of the following or equal:
  - 1. Romac Industries, Inc.
  - 2. Smith-Blair Inc.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. General:
  - 1. Piping drawings:
    - a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
    - b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
      - 1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
  - 2. Piping alternatives:
    - a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
    - b. Alternative pipe ratings:
      - 1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
      - 2) Piping of different material may not be substituted in lieu of specified piping.
    - c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
    - d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
      - 1) Manufacturer's factory trained representative:
        - a) Provide on-site training for Contractor's field personnel.
        - b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
      - 2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
    - e. Flanged joints: where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.



3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.
- B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
  2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
    - a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
    - b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
    - c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
    - d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
  3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
  4. Core drilled openings:
    - a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
    - b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
    - c. Remove dust and debris from hole using compressed air.
- C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
    - a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
      - 1) Slope plumbing drain piping with a minimum of 1/4-inch per foot downward in the direction of flow.
  2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
  3. Support piping: As specified in Sections 15061 - Pipe Supports, 15062 - Preformed Channel Pipe Support System, and 15063 - Non-Metallic Pipe Support System:
    - a. Do not transfer pipe loads and strain to equipment.
  4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
  5. Assemble piping without distortion or stresses caused by misalignment:
    - a. Match and properly orient flanges, unions, flexible couplings, and other connections.
    - b. Do not subject piping to bending or other undue stresses when fitting piping.



- c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
  - d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
  - e. Alter piping assembly to fit, when proper fit is not obtained.
  - f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.
- D. Buried piping:
  - 1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
  - 2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
    - a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
  - 3. Laying piping:
    - a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
    - b. Place piping with top or bottom markings with markings in proper position.
    - c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
    - d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
    - e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
  - 4. Concrete encase buried pipe installed under concrete slabs or structures.
- E. Venting piping under pressure:
  - 1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
  - 2. Install plug valves as air bleeder cocks at high points in piping.
    - a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
  - 3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
  - 4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09960 - High-Performance Coatings.
- F. Condensate in digester gas piping:
  - 1. Slope digester gas piping to drip traps or low-point drains at minimum 1/2-inch per foot where condensate flows against the gas or 1/4-inch per foot where condensate flows with gas.
  - 2. Install tapered filler pieces between flanges at high points of straight runs to provide for slope reversals.
    - a. Do not subject piping to high stresses in order to change direction.
  - 3. Provide pipe taps, threaded nipples, and 1-inch plug valves at low points in concrete utility boxes with lids.





- G. Restraining buried piping:
  - 1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    - a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
    - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
  - 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
  - 3. Place concrete thrust blocks against undisturbed soil.
  - 4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
  - 5. Provide underground mechanical restraints where specified in the Piping Schedule.
- H. Restraining above ground piping:
  - 1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    - a. When piping is aboveground or underwater, use mechanical or structural restraints.
    - b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
  - 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
- I. Connections to existing piping:
  - 1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
    - a. Protect domestic water/potable water supplies from contamination:
      - 1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
      - 2) Provide devices approved by Owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
  - 2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
  - 3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
  - 4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.
- J. Connections to in-service piping:
  - 1. As specified in Section 01140 - Work Restrictions.



- K. Connections between ferrous and nonferrous metals:
  - 1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
  - 2. Nonferrous metals include aluminum, copper, and copper alloys.
- L. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
  - 1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

### **3.02 CLEANING**

- A. Piping cleaning:
  - 1. Upon completion of installation, clean piping interior of foreign matter and debris.
  - 2. Perform special cleaning when required by the Contract Documents.
- B. Cleaning potable water piping:
  - 1. Flush and disinfect potable water piping as specified in Section 01757 - Disinfection.
- C. Cleaning air piping:
  - 1. Perform special cleaning of filtered air piping from the intake clean air plenums to the discharge points and high-pressure air piping.
    - a. Protect surfaces from contamination.
  - 2. Special cleaning shall include wire brushing, power tool cleaning, wiping down with lint-free cloths, brooming, and vacuuming to remove rust, scale, weld spatter, dust, dirt, oil, and other matter deleterious to operation of the air system:
    - a. Do not sandblast installed piping.
  - 3. To the greatest extent possible, clean piping immediately prior to final closure of piping systems:
    - a. Enter piping, clean and wipe down surfaces, and vacuum out residue.
    - b. Clean surfaces not accessible to this cleaning operation after installation within 6 hours preceding installation.
  - 4. Subsequent to cleaning, protect surfaces from contamination by dust, dirt, construction debris, and moisture, including atmospheric moisture:
    - a. Whether or not pipe upstream has been cleaned, temporarily seal openings in partially completed work except when installation is actively in progress.
    - b. When installation is actively in progress, seal openings at the end of each day's construction or when construction is temporarily stopped.
  - 5. Suspend cleaning and seal openings when inclement weather, including dust storms, is imminent.
  - 6. Use clean, dry air for testing the piping and other elements of the system.
  - 7. Prior to introduction of air to the system, blow piping clean.
    - a. Blow with maximum discharge rate possible for minimum 4 hours, using new blowers or compressors and filters.
  - 8. Clean surfaces that become contaminated prior to acceptance.
- D. Conduct pressure and leak test, as specified.





### 3.03 PIPING SCHEDULE



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>DR</b>	<b>Drain</b>										
	Underground	2-12	PVC	SCH 80	15249 - Polyvinyl Chloride (PVC) Pipe	SW	15 feet/GR	None	None		
	Aboveground	0.5-6	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL or SW	15 feet/GR	None	WBA		
<b>DG</b>	<b>Digester Gas</b>										
	Aboveground (Inside)	3-6	SST	SCH 10S	15286 - Stainless Steel Pipe	WLD or FL, FL where shown	15 psig/LH	None	None		
	Aboveground (Outside)	3-12	SST	SCH 10S	15286 - Stainless Steel Pipe	WLD or FL, FL where shown	15 psig/LH	None	None		Insulate per Specification Section 15082
<b>DS</b>	<b>Digested Sludge</b>										
	Aboveground	10-20	DIP	CL 53	15211 - Ductile Iron Pipe: AWWA C151	FL or GE	100 psig/HH	P401	EPP		



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>FOG</b>	<b>Fats, Oils, Grease</b>										
	Underground	4-6	DIP	250	15211 – Ductile Iron Pipe: AWWA C151	Mech. Rest. MJ	200 psig /HH	GL	2 Layers PEE	180 deg. F	
	Aboveground	4-6	DIP	CL 53	15211 – Ductile Iron Pipe: AWWA C151	GE	100 psig /HH	GL	EPP	180 deg. F	Insulate per Specification Section 15082 where shown on Drawings
<b>HWR</b>	<b>Hot Water Return</b>										
	Underground	4	DIP	250	15211 – Ductile Iron Pipe: AWWA C151	B&SP	45 psig/HH	None	2 Layers of PEE		
	Aboveground	4	DIP	CL 53	15211 – Ductile Iron Pipe: AWWA C151	FL or GE	45 psig/HH	None	EPP		Insulate per Specification Section 15082



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>HWS</b>	<b>Hot Water Supply</b>										
	Underground	4	DIP	250	15211 – Ductile Iron Pipe: AWWA C151	B&SP	45 psig/HH	None	2 Layers PEE		
	Aboveground	4	DIP	CL 53	15211 – Ductile Iron Pipe: AWWA C151	FL or GE	45 psig/HH	None	EPP		Insulate per Specification Section 15082
<b>LP</b>	<b>Liquid Propane</b>										
	Underground	0.5-2	BSP	SCH 40	15270 – Steel Pipe: ASTM A53 - Plant	SCRD or FL	SC	None	PTW		
	Aboveground	0.5-2	BSP	SCH 40	15270 – Steel Pipe: ASTM A53 - Plant	SCRD or FL	SC	None	EPP		Insulate per Specification Section 15082
<b>OF</b>	<b>Overflow</b>	4-10	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL	25 psig/AM	None	WBA		



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<b>NPW</b>	<b>Non-Potable Water</b>										
	Underground	1-3	PVC	SCH 80	15249 - Polyvinyl Chloride (PVC) Pipe	SW	125 psig /HH	None	None		
		4-10	DIP	150	15211 - Ductile Iron Pipe: AWWA C151	Mech Rest. MJ	125 psig/HH	CM	2 layers PEE		
	Aboveground	0.5-3	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL or SW	125 psig/HH	None	WBA		
<b>V</b>	<b>Vent</b>	6	CPVC	SCH 80	15259 - Chlorinated Polyvinyl Chloride (CPVC) Pipe	FL or SW	25 psig/AM	None	WBA		



PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
<p>Abbreviations:</p> <p>1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 15956 - Piping Systems Testing.</p> <p>AM Air method</p> <p>GR Gravity method</p> <p>HH High head method</p> <p>LH Low head method</p> <p>SC Special case</p> <p>2. Abbreviations to designate piping include the following:</p> <p>B&amp;SP Bell and spigot</p> <p>BSP Black Steel Pipe</p> <p>CI Cast iron</p> <p>CISP Cast iron soil pipe</p> <p>CL Class, followed by the designation</p> <p>CM Cement mortar</p> <p>CTP Coal tar pitch</p> <p>DIP Ductile iron piping</p> <p>EPP Epoxy polyurethane coating</p> <p>FL Flange</p> <p>GA Gauge, preceded by the designation</p>						<p>GE Grooved end joint</p> <p>GL Glass lined</p> <p>GSP Galvanized steel pipe</p> <p>MJ Mechanical joint</p> <p>NPS Nominal pipe size, followed by the number in inches</p> <p>psi pounds per square inch</p> <p>psig pounds per square inch gauge</p> <p>PE Polyethylene</p> <p>PEE Polyethylene encasement</p> <p>PTW Polyethylene tape wrap</p> <p>PVC Polyvinyl Chloride</p> <p>SCH Schedule, followed by the designation</p> <p>SCRD Screwed-On</p> <p>SST Stainless steel</p> <p>SW Solvent welded</p> <p>VCP Vitrified clay piping</p> <p>WBA Waterborne acrylic</p> <p>WLD Weld</p>					

END OF SECTION



## **SECTION 15061**

### **PIPE SUPPORTS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

##### **1.02 REFERENCES**

- A. ASTM International (ASTM):
  - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  - 3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- B. Manufacturer's Standardization Society (MSS):
  - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures
- B. Product data.
  - 1. Design features.
  - 2. Load capacities.
  - 3. Material designations by UNS alloy number or ASTM Specification and Grade.
  - 4. Data needed to verify compliance with the Specifications.
  - 5. Catalog data.
  - 6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

##### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

#### **PART 2 PRODUCTS**

##### **2.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements.



## 2.02 MATERIALS

- A. General:
  - 1. Hot dip galvanized:
    - a. Fabricate as specified in Section 05120 - Structural Steel.
    - b. Hot dip after fabrication of support in accordance with ASTM A123.
    - c. Repair galvanized surface as specified in Section 05120 - Structural Steel.
  - 2. Stainless steel.
    - a. Fabricate as specified in Section 05120 - Structural Steel.
    - b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
    - c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or A967.
      - 1) Passivation treatments using citric acid are not allowed.
    - d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.
- B. Outdoor areas: Areas exposed to the natural outdoor environment:
  - 1. Coated steel, as specified in Section 09960 Hot Dip Galvanized.
- C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
  - 1. Coated steel, as specified in Section 09960.
- D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
  - 1. Type 316L Stainless Steel.
- E. Stainless steel piping system:
  - 1. Type 304 Stainless Steel.
- F. Chemical containment areas and chemical piping:
  - 1. Type 316L Stainless Steel.
- G. Fasteners:
  - 1. As specified in Section 05120 - Structural Steel.

## 2.03 PIPE SUPPORTS

- A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
  - 1. Manufacturers: One of following or equal:
    - a. For stainless steel piping:
      - 1) Bergen-Power, Figure 133.
      - 2) Nibco-Tolco, Figure 103.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 140.
      - 2) Bergen-Power, Figure 133.
      - 3) Cooper B-Line Systems, Inc., Figure B3205.





- B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Bergen-Power, Figure 94.
      - 2) FM Stainless Fasteners.
    - b. For steel and ductile iron piping:
      - 1) Anvil International, Figure 146.
      - 2) Bergen-Power, Figure 94.
- C. Eye bolts:
  - 1. For stainless steel piping:
    - a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
  - 2. For all other piping, unless indicated on the Drawings:
    - a. Welded and rated equal to full load capacity of rod.
- D. Welded eyebolt rod:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 101.
      - 2) FM Stainless Fasteners.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 278.
      - 2) Bergen-Power, Figure 93.
      - 3) Cooper B-Line Systems, Inc., Figure B3210.
- E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 1C.I.
      - 2) Bergen-Power, Figure 100SS.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 97.
      - 2) Cooper B-Line Systems, Inc., Figure B3172.
- F. Adjustable clevis hangers: MSS SP-58, Type 1:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
      - 2) FM Stainless Fasteners, Figure 60.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 260 or Figure 590.
      - 2) Bergen-Power, Figure 100.
      - 3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
- G. Adjustable clevis hangers for insulated pipe: Oversize:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 1A.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 300.



- 2) Bergen-Power, Figure 100EL.
  - 3) Cooper B-Line Systems, Inc. Figure B3108.
- H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 324.
      - 2) Cooper B-Line Systems, Inc., Figure B3110.
      - 3) FM Fasteners, Figure 81.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 181.
      - 2) Cooper B-Line Systems, Inc., Figure B3110.
- I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) FM Stainless Fasteners, Figure 71.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 171.
      - 2) Cooper B-Line Systems, Inc., Figure B3114.
- J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 30M.
      - 2) Cooper B-Line Systems, Inc., Figure B3066.
      - 3) FM Stainless Fasteners, Figure 98.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 195.
      - 2) Cooper B-Line Systems, Inc., Figure B3066.
- K. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
1. Manufacturers: One of following or equal:
    - a. Anvil International, Figure 199.
    - b. Cooper B-Line Systems, Inc., Figure B3067.
- L. Standard U-bolt: MSS SP-58, Type 24:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 110.
      - 2) Cooper B-Line Systems, Inc., Figure B3188.
      - 3) FM Stainless Fasteners, Figure 37.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 137.
      - 2) Bergen-Power, Figure 283.
      - 3) Cooper B-Line Systems, Inc., Figure B3188.
- M. Riser clamps: MSS SP-58, Type 8:
1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Cooper B-Line Systems, Inc., Figure B3373.



- 2) FM Stainless Fasteners, Figure 61.
  - b. For all other piping, unless indicated on the Drawings:
    - 1) Anvil International, Figure 261.
    - 2) Bergen-Power, Figure 126.
    - 3) Cooper B-Line Systems, Inc., Figure B3373.
- N. Pipe clamps: MSS SP-58, Type 4:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 4.
      - 2) Cooper B-Line Systems, Inc., Figure 3140.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 212.
      - 2) Bergen-Power, Figure 175.
      - 3) Cooper B-Line Systems, Inc., Figure B3140.
- O. Adjustable offset pipe clamp:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 4.
      - 2) Cooper B-Line Systems, Inc., Figure B3149.
      - 3) FM Stainless Fasteners, Figure 63.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 100.
      - 2) Cooper B-Line Systems, Inc., Figure B3149.
- P. Offset pipe clamp:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 8.
      - 2) Cooper B-Line Systems, Inc., Figure 3148.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 103.
      - 2) Cooper B-Line Systems, Inc., Figure B3148.
- Q. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 318.
      - 2) FM Stainless Fasteners, Figure 59.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 259.
      - 2) Bergen-Power, Figure 125.
      - 3) Cooper B-Line Systems, Inc., Figure B3090.
    - c. Threaded pipe stand support stanchion. Match pipe support material.
      - 1) Anvil International, Figure 63T.
      - 2) Bergen-Power, Figure 138.
      - 3) Cooper B-Line Systems Inc., Figure B3088ST.



- R. Spring hangers:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Bergen-Power, Figure 920.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure B-268, Type G.
      - 2) Bergen-Power, Figure 920.
- S. One hole pipe clamps:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping: Engineer knows of no product.
    - b. For all other piping:
      - 1) Anvil International, Figure 126.
      - 2) Carpenter & Paterson, Figure 237S.
- T. Welded beam attachment: MSS SP-58, Type 22:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 304.
      - 2) Cooper B-Line Systems, Inc., Figure 3083.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 66.
      - 2) Bergen-Power, Figure 113A or 113B.
      - 3) Cooper B-Line Systems, Inc., Figure B3083.
- U. Heavy pipe clamp: MSS SP-58, Type 4:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 4H.
    - b. For all other piping, unless called out otherwise on the drawings:
      - 1) Anvil International, Figure 216.
      - 2) Bergen-Power, Figure 298.
- V. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
  - 1. Manufacturers: One of the following or equal:
    - a. For stainless steel piping:
      - 1) Nibco-Tolco, Figure 426.
    - b. For all other piping, unless indicated on the Drawings:
      - 1) Anvil International, Figure 257, Type 3.
      - 2) Cooper B-Line Systems, Inc., Figure B3893.
- W. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 - Structural Steel.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.



- B. Field verify support location, orientation, and configuration to eliminate interference prior to fabrication of supports.
- C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.
- D. Use flush shells only where indicated on the Drawings.
- E. Do not use anchors relying on deformation of lead alloy.
- F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1-inch to concrete, masonry, or wood.
- G. Suspend pipe hangers from hanger rods and secure with double nuts.
- H. Install continuously threaded hanger rods only where indicated on the Drawings.
- I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.
- J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.
- K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
  - 1. For stainless steel piping, use stainless steel U-bolts.
  - 2. For all other piping, use galvanized U-bolts.
- L. Support spacing:
  - 1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
  - 2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
  - 3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
  - 4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
  - 5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.
- M. Install supports at:
  - 1. Any change in direction.
  - 2. Both sides of flexible pipe connections.
  - 3. Base of risers.
  - 4. Floor penetrations.
  - 5. Connections to pumps, blowers, and other equipment.
  - 6. Valves and appurtenances.
- N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.
- O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.



- P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.
- Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.
- R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.
- S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.
- T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.
- U. Where pipe is insulated, install over-sized supports and hangers.
- V. Install insulation shield in accordance with MSS SP-58, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the Drawings.
- W. Install riser clamps at floor penetrations and where indicated on the Drawings.
- X. Coat support system components as specified in Section 09960 - High-Performance Coatings.

END OF SECTION



## SECTION 15063

### NON-METALLIC PIPE SUPPORT SYSTEM

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Non-metallic pipe support system including the following:
  - 1. Channel framing, and components.
  - 2. Pipe clamps.
  - 3. Fittings.
  - 4. Fasteners.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. E84 - Test Method for Surface Burning Characteristics of Building Materials.

##### 1.03 SYSTEM DESCRIPTION

- A. Design responsibility:
  - 1. The manufacturer of the non-metallic pipe support system shall be considered the designer of the support system.
  - 2. Prepare design calculations utilizing the design criteria included in these Specifications.
  - 3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.
- B. Design requirements:
  - 1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
  - 2. Maximum allowable deflection: 1/240 of span.
  - 3. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
  - 4. Future loads:
    - a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
    - b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
    - c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
  - 5. Seismic design criteria: As specified in Section 01612 - Seismic Design Criteria as specified for mechanical equipment.
  - 6. Spacing of supports: As required to comply with design requirements but not more than 5 feet.



## **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings.
- C. Calculations.

## **1.05 QUALITY ASSURANCE**

- A. Supply materials from a single manufacturer with sole responsibility for the pipe support system.
- B. The supplied system, including pipe clamps, shall be interchangeable with industry standard 1-5/8-inch steel and fiberglass channel framing systems.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Transportation, handling, storage, and installation shall be in accordance with the manufacturers printed instructions.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

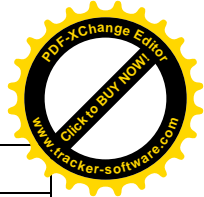
- A. One of the following or equal:
  - 1. StrutTech.
  - 2. Unistrut.

## **2.02 MATERIALS**

- A. Fiberglass resin: Corrosion-resistant premium grade vinylester.
- B. Injection molded components: Polyurethane thermoplastics.
- C. Flame spread of fiberglass:
  - 1. Vinylester fiberglass (Series VF): Class 1, ASTM E84.
  - 2. Polyurethane: V-O UL 94V.
- D. Physical properties of fiberglass:

	<b>Longitudinal</b>	<b>Transverse</b>
Tensile Strength	37,500 pounds per square inch, (psi)	10,000 pounds per square inch, (psi)
Tensile Modules	3.0 X 10 <sup>6</sup> psi	1.0 X 10 <sup>6</sup> psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0 X 10 <sup>6</sup> psi	1.0 X 10 <sup>6</sup> psi
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi





	Longitudinal	Transverse
Izod Impact	30 foot-pounds per square inch	5 foot-pounds per square inch

- E. Surface veil: Fiberglass channel shall have polyester surface veil over 100 percent of the surface to provide protection against degradation from ultraviolet light.
- F. Touch-up resin:
  - 1. Manufacturers: The following or equal:
    - a. Krylon, 7006-Satin Polyurethane Clear Finish.

## 2.03 COMPONENTS

- A. Channel framing:
  - 1. All channel framing shall be supplied with integral notches 1-inch on center.
  - 2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.
- B. Pipe clamps:
  - 1. Adjustable type: Non-metallic and non-conductive.
  - 2. Fixed type:
    - a. Pipe clamps for pipe less than 6 inches in diameter shall be non-metallic and non-conductive.
    - b. Pipe clamps for pipe equal to and greater than 6 inches in diameter shall be fiberglass.
- C. Channel fittings:
  - 1. Make fittings and post bases from glass-filled polyurethane or polyester.
- D. Fasteners:
  - 1. Make fasteners from one of the following materials:
    - a. Glass-filled polyurethane.
    - b. Vinylester fiberglass.
- E. Cushion strip:
  - 1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets this criteria.
    - a. Manufacturers: One of the following or equal:
      - 1) Anvil, AS 3795.
      - 2) Unistrut, P2600 Unicushion.



## **ART 3     EXECUTION**

### **3.01    INSTALLATION**

#### **A.    General:**

1.    Install in accordance with manufacturer's instructions, shop drawings, and as indicated on the Drawings.
2.    Seal machined edges and holes with touch-up resin.

**END OF SECTION**



## SECTION 15075

### EQUIPMENT IDENTIFICATION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Equipment nameplates.
  - 2. Special items.

##### 1.02 SUBMITTAL

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Shop drawings:
  - 1. Product data.
  - 2. Installation instructions.
- C. Samples.

##### 1.03 QUALITY ASSURANCE

- A. Regulatory requirements: Comply with Arkansas Department of Environmental Quality (ADEQ) Arkansas Pollution Control and Ecology Commission (AP&EC) Regulation 6.

#### PART 2 PRODUCTS

##### 2.01 EQUIPMENT NAMEPLATES

- A. Material and fabrication:
  - 1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for fasteners.
- B. Fasteners:
  - 1. Number 4 or larger oval head stainless steel screws or drive pins.
- C. Text:
  - 1. Manufacturer's name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.

##### 2.02 SPECIAL ITEMS

- A. In addition, special coating of following items will be required:



Item	Color
Valve handwheels and levers	Red
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

- B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. Verify satisfactory conditions of substrate for applying identification.
- B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

#### **3.02 PREPARATION**

- A. Prepare and coat surfaces of special items as specified in Section 09960 - High-Performance Coatings.
- B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION



## SECTION 15076

### PIPE IDENTIFICATION - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Pipe identification including the following:
  - 1. Pipe identification by color and legend.
  - 2. Underground warning tape.
  - 3. Tracer wire.
  - 4. Witness markers.
  - 5. Valve identification.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. A13.1 - Scheme for the Identification of Piping Systems.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Submit following:
  - 1. Product data.
  - 2. Samples.
  - 3. Manufacturer's installation instructions.
  - 4. Submit following as specified in Section 01770 - Closeout Procedures:
    - a. Operation and Maintenance Data.
    - b. Warranty.

#### PART 2 PRODUCTS

##### 2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

- A. Manufacturers:
  - 1. One of the following or equal:
    - a. Seton, Opti Code Pipe Markers.
    - b. Lab Safety Supply.
    - c. Marking Services, Inc.
- B. Materials:
  - 1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
    - a. Lettering:



Nominal Pipe Diameter	Lettering Size
Less than 1.5 inches	1/2-inch
1.5 inches to 2 inches	3/4-inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

b. Marker colors:

Service	Lettering	Background
Flammables, chemicals, toxics	Black	Yellow
Water, nontoxic solutions or low hazard liquids	White	Green
Nonflammable or nontoxic gases	White	Blue
Fire quenching fluids (foam, fire water, CO <sub>2</sub> Halon)	White	Red

2. Coating: As specified in Section 09960 - High-Performance Coatings.
3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4-inch high identifying lettering.
4. Pipe identification tag chains: Aluminum or stainless steel.
5. Snap-on markers: Markers with 3/4-inch high letters for 3/4 to 4-inch pipe or covering, or 5-inch high letters for 5-inch or larger pipe or cover:
  - a. Manufacturers: One of following or equal:
    - 1) Brady BradySnap-On B-915.
    - 2) Seton Setmark.

## 2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:

1. Manufacturer: One of the following or equal:
  - a. Seton Name Plate Co.
  - b. T. Christy Enterprises, Inc.
2. Material:
  - a. Polyethylene tape for prolonged underground use.
  - b. Minimum tape thickness: 4 mils.
  - c. Overall tape width: 6 inches.
  - d. Message: "CAUTION" with the name of the service followed by "LINE BURIED BELOW." in black lettering on colored background in accordance with approved APWA colors.
    - 1) Water: Blue.
    - 2) Sewer: Green.
    - 3) Telephone: Orange.
    - 4) Gas and other services: Yellow.
  - e. Aluminum backing or solid aluminum core.

B. Tracer wire:

1. Manufacturers: One of the following or equal:
  - a. Kris-Tech Wire.



- b. Corpro.
- 2. Materials: One of the following or equal:
  - a. Solid copper conductor
  - b. Thickness minimum: 10 gauge.
  - c. Insulation:
    - 1) Match insulation color to the color of the pipe being installed.
    - 2) UF type, direct bury.
    - 3) 30 mil HMWPE.
- 3. Splicing Kit:
  - a. Manufacturers: One of the following or equal:
    - 1) Ryall Electric Co., 3M Kit#82-A1.
- 4. Station Box:
  - a. Lid and collar materials: Cast iron.
  - b. Able to withstand heavy traffic loading.
  - c. Manufacturers: One of the following or equal:
    - 1) Farwest Corrosion Control Co, Glenn 4 Test Station.
- C. Witness markers:
  - 1. Manufacturers: One of the following or equal:
    - a. Carsonite Composites, Utility Marker.
    - b. Hampton Technical Associates, Inc.
  - 2. Materials:
    - a. Glass fiber and resin reinforced thermosetting composite material.
    - b. UV resistant.
  - 3. Constructed as a single piece.
  - 4. Pointed at the bottom end.
  - 5. Information to be included on the marker:
    - a. "Caution" (type of service) "Pipeline".
    - b. Phone number for Underground Service Alert.
    - c. Phone number for Owner in case of emergency.
    - d. Station number.
    - e. Offset:
      - 1) Only provide offset if marker is not directly over the pipe.
    - f. Name of appurtenance or fitting (e.g. 45, BO, ARV, etc.)

## **2.03 VALVE AND GATE IDENTIFICATION**

- A. Provide valve and gate schedule for each valve and gate in the Work with the following information:
  - 1. Identification number.
  - 2. Location.
  - 3. Type.
  - 4. Function.
  - 5. Normal operating position.
- B. Identification tag requirements.
  - 1. Diameter: 2-inches.
  - 2. Material:
    - a. Buried applications: Stainless steel.
    - b. Buried applications with concrete marker: Brass.
    - c. Above ground and in-chase applications: 19 gauge aluminum or PVC.
  - 3. Stamp tags in 1/4-inch high letter:



4. Provide non-corrosive metal wire suitable for attaching the tag to the operator base.
  5. Secure tags to valve or gate:
    - a. Attach tags in such a way as to allow free and full operation of the valve or gate.
  6. Buried applications with concrete marker: Secure tags to concrete marker.
- C. Submittal requirements:
1. Submit 2 samples of the type of tag proposed and the manufacturer's standard color chart and letter styles to the Engineer for review.
- D. Manufacturer: The following or equal:
1. Seton Name Plate Co.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify satisfactory conditions of substrate for applying identification.
- B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

### **3.02 PREPARATION**

- A. Prepare and coat surfaces as specified in Section 09960 - High-Performance Coatings.
- B. Prepare surface in accordance with product manufacturer's instructions.

### **3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION**

- A. Identify exposed piping, valves, and accessories in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.
- B. Color code:
  1. Paint piping with colors as scheduled in Piping Color Code and Marker Schedule.
- C. Lettering and flow direction arrows:
  1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4-inch high letters on 3/4 through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
  2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.
- D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.





- E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.
- F. Metal tags:
  - 1. Where outside diameter of pipe or pipe covering is 5/8-inch or smaller, provide metal pipe identification tags instead of lettering.
  - 2. Fasten pipe identification tags to pipe with chain.
  - 3. Where tags are used, color code pipe as scheduled.

### **3.04 BURIED PIPING IDENTIFICATION**

- A. Underground warning tape:
  - 1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.
- B. Tracer wire:
  - 1. Install on all non-metallic pipe.
  - 2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
  - 3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
  - 4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
    - a. Twisting the wires together is not acceptable.
- C. Witness markers:
  - 1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
  - 2. Place markers at appurtenances located in unpaved areas.
  - 3. Embed markers at least 18 inches into the soil.

### **3.05 APPLICATION**

- A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.
- B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15-foot spacing on piping runs.
- C. Provide piping marker letters and colors as scheduled.
- D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

### **3.06 PIPING COLOR CODE AND MARKER SCHEDULE**

Service Fluid	Pipe Color	Marker Legend
Digester Sludge	Dark Brown	DIGESTER SLUDGE
FOG	Dark Brown	FOG



Service Fluid	Pipe Color	Marker Legend
Non-Potable Water	Light Blue	NON-POTABLE WATER
Potable Water	Light Blue	POTABLE WATER
Hot Water Supply	Light Gray	HOT WATER SUPPLY
Hot Water Return	Light Gray	HOT WATER RETURN
Tank Drain	Charcoal	TANK DRAIN
Vent Pipe	Yellow	VENT PIPE
Digester Gas	Red	DIGESTER GAS
Propane	Red	PROPANE

Letters	Color of Pipe	Color of Bands	Color of Letters
Digester Sludge	Dark Brown	None	White
FOG	Dark Brown	None	White
Non-Potable Water	Light Blue	Dark Gray	Black
Potable Water	Light Blue	None	Black
Hot Water Supply	Light Gray	White	Black
Hot Water Return	Light Gray	Black	Black
Tank Drain	Charcoal	None	White
Vent Pipe	Yellow	None	Black
Digester Gas	Red	Yellow	White
Propane	Red	None	White

END OF SECTION



## SECTION 15082

### PIPING INSULATION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Insulation for piping and related systems that are not plumbing systems.

##### 1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. Standard Specifications for Highway Bridges.
- B. ASTM International (ASTM):
  - 1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
  - 2. C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
  - 3. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
  - 4. C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
  - 5. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
  - 6. C552 - Standard Specification for Cellular Glass Thermal Insulation.
  - 7. C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
  - 8. C929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
  - 9. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
  - 10. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  - 11. D2310 - Standard Classification of Machine-Made "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
  - 12. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
  - 13. E96 - Standard Test Methods for Water Vapor Transmission of Materials.

##### 1.03 DEFINITIONS

- A. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.
- B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.



- C. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.
- D. Flame spread and smoke density: Burning characteristics determined in accordance with ASTM E84.
- E. Interior: Piping that is installed inside a building.
- F. K factor: Thermal conductivity determined in accordance with ASTM C177 or C518.
- G. Mineral fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
- H. Water vapor permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

#### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
  - 1. Insulation properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
  - 2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
  - 3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.
  - 4. Pre-insulated ductile iron piping: In addition to information required for insulation and jacket as specified above and information required as specified in Section 15211 - Ductile Iron Pipe: AWWA C151 for ductile iron piping, include catalog cutsheets, specifications, installation instructions, backfill procedures, and dimensioned drawings for pre-insulated ductile iron piping system.
  - 5. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.
  - 6. Laboratory report: Provide certified laboratory report stating that insulation is not manufactured using chlorinated polymers and does not contain chlorides, bromides, sulfates, or fire-rated materials.
- C. Provide warranty as specified in Section 01783 - Warranties and Bonds.

#### **1.05 REGULATORY REQUIREMENTS**

NOT USED



## PART 2 PRODUCTS

### 2.01 PIPE INSULATION, GENERAL REQUIREMENTS

- A. As specified in Section 01600 - Product Requirements.
- B. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

TABLE 1. Required Insulation Thicknesses

Required Insulation Thicknesses (inches)					
Service Temperature Range as Designated in Insulation Schedule at End of this Section	Nominal Pipe Diameters				
	1 inch and Less	1.25 to 2 inches	2.5 to 4 inches	5 to 10 inches	Over 10 inches
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0

### 2.02 PIPE INSULATION

- A. Insulation types: Provide in accordance with the insulation types listed and scheduled.
- B. Insulation, Type 1:
  - 1. Insulation material: Closed cell elastomeric insulation.
  - 2. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
  - 3. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
  - 4. Fire ratings:
    - a. Flame spread: 25 or less.
    - b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
  - 5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.
  - 6. Manufacturers: One of the following or equal:
    - a. Armacell, AP Armaflex.
    - b. Aeroflex USA Inc., Aerocel® AC.
- C. Insulation, Type 2:
  - 1. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
    - a. In accordance with ASTM C547, Class 1.
    - b. Provide with factory installed vapor barrier.



- 1) Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type I.
- 2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
- 3) Circumferential butt seals: 4-inch wide tape or similar properties or 4-inch wide overlap with adhesive seal.
- 4) Vapor barrier permeability: 0.02 perms or lower.
- 5) Vapor barrier flame spread rating: 25 or less.
2. Minimum temperature range: Minus 0 degrees Fahrenheit to plus 850 degrees Fahrenheit.
3. K factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-inch/hour-square feet degrees Fahrenheit.
4. Maximum moisture absorption, volume percent: 5.
5. Manufacturers: One of the following or equal:
  - a. Owens-Corning , Fiberglas™ FLEXWRAP® ASJ
  - b. Johns Manville, Micro-Lok® HP.
  - c. Knauf Insulation, Earthwool® Redi-Klad® 1000° Pipe Insulation.
- D. Insulation, Type 3:
  1. Insulation material: Rigid cellular glass in accordance with ASTM C552, Type II.
  2. Temperature range: Minus 450 degrees Fahrenheit to plus 900 degrees Fahrenheit.
  3. K factor at 75 degrees Fahrenheit: Not more than 0.32 BTU-inch/hour-square feet-degrees Fahrenheit.
  4. Minimum average density: 7.5 pounds per cubic foot.
  5. Maximum moisture absorption, volume percent: 5.
  6. Minimum compressive strength: 87 pounds per square inch.
  7. Moisture permeability: 0.00 perm-inch.
  8. Manufacturers: One of the following or equal:
    - a. Owens- Corning, Foamglas® One™.
- E. Insulation, Type 4:
  1. Insulation material: Asbestos-free, rigid calcium silicate in accordance with ASTM C533; Type I for process temperatures up to 1,200 degrees Fahrenheit.
  2. K factor at 500 degrees Fahrenheit: 0.55 for Type I.
  3. Maximum average (dry) density: 14.5 pounds per cubic foot.
  4. Compressive strength: 100 pounds per square inch, to produce a 5-percent compression.
  5. Manufacturers: The following or equal: In accordance with ASTM C533 Type I:
    - a. Johns Manville, Thermo-12 Gold.

## **2.03 INSULATION JACKETS**

- A. Jacket, Type 1:
  1. Material: 28 ounces per square yard polyvinyl chloride on polyester fabric; total thickness 0.028-inch minimum.
  2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
  3. Color: As selected by the Engineer from manufacturer's standard colors.
  4. Overlap: 1-inch minimum at joints and fittings.
  5. Joint seal: Self-sealing lap tape.



6. Fittings: Factory made with full thickness insulation.
  7. Manufacturers: The following or equal:
    - a. Techlite® Insulation, 379 SSL Series.
- B. Jacket, Type 2:
1. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
  2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
  3. Color: White.
  4. Overlap: 1-inch minimum at joints and fittings.
  5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
  6. Fittings: Factory made with full thickness insulation.
  7. Manufacturers: One of the following or equal:
    - a. Johns Manville, Zeston® 2000 PVC.
    - b. Proto Corp., LoSMOKE PVC.
    - c. Speedline® Corp., Smoke-Safe™ PVC.
- C. Jacket, Type 3:
1. Material: Aluminum, Alloy 5005; 0.016-inch (26-gauge) minimum thickness.
  2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
  3. Bands: 0.5-inch wide, 0.0508-inch (16-gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
  4. Joint seal: Apply waterproof adhesive at joints and overlaps.
  5. Fittings: Custom fit of same materials.
  6. Manufacturers: One of the following or equal:
    - a. Childers Products.
    - b. Premetco International.

## **2.04 VAPOR BARRIERS**

- A. Vapor barrier, Type 1:
1. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
  2. Permeability: 0.02 perms or lower.
  3. Maximum flame spread rating: 25.
  4. Edge seal: Pressure-sensitive tape lap seal.
  5. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
- B. Vapor barrier, Type 2:
1. Material: Mastic.
  2. Manufacturers: One of the following or equal:
    - a. Benjamin Foster, No. 30-76.
    - b. Insul-Coustic, No. I.C.-580.
    - c. Foster Products, 36-10/46-10 Weatherite.
    - d. Childers Products CP10/11 Vi-Acrl.





## 2.05 RELATED MATERIALS

- A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard-duty adhesives are not permitted.

## 2.06 REMOVABLE INSULATING BLANKETS

- A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.
- B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3 inches in nominal size and larger. Insulate equipment and piping appurtenances less than 3 inches with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.
- C. Manufacturers: One of the following, or equal:
  - 1. Thermal Energy Products, Inc., Energy Wrap.
  - 2. Accessible Products, Thermazip 2000 Jacket.
  - 3. Owens Corning, Temp-Mat.
- D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
  - 1. Use: For service temperatures up to 800 degrees Fahrenheit.
  - 2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees Fahrenheit.
  - 3. Cover: 17-ounce fabric with both sides covered with silicone-impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
  - 4. Cover fasteners: Use one of the following systems:
    - a. Grommets in the blanket and stainless steel wire.
    - b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.
- E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit:
  - 1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit.
  - 2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
  - 3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
  - 4. Cover fasteners: Use one of the following systems:
    - a. Grommets in the blanket and stainless steel wire.
    - b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

## 2.07 SHIPPING

- A. As specified in Section 01600 - Product Requirements.





## PART 3 EXECUTION

### 3.01 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01600 - Product Requirements.
- B. Store insulation materials and accessories under cover and protected from moisture.
- C. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

### 3.02 PREPARATION

- A. Pressure test piping and complete application of coating system before applying insulation.
- B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.
- C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

### 3.03 INSULATION SCHEDULE

TABLE 2. Insulation Schedule

Service Designation <sup>(1)</sup>	Location <sup>(2)</sup>	Insulation Type <sup>(3)</sup>	Jacket Type <sup>(2,3)</sup>	Service Temp. °F <sup>(4)</sup>	Vapor Barrier
Digester Gas (DG)	Exterior	3	3	60 – 120	Type 2
Hot Water Supply (HWS)	Exterior	3	3	100-200	Type 2
Hot Water Return (HWR)	Exterior	3	3	100-200	Type 2
Hot Water Supply (HWS)	Interior	2	3	100-200	Type 2
Hot Water Return (HWR)	Interior	2	3	100-200	Type 2
Fats, Oils, Grease (FOG)	Exterior	3	3	Below 180	Type 2
Fats, Oils, Grease (FOG)	Interior	2	3	Below 180	Type 2
Non-Potable Water	Exterior	2	3	Below 70	Type 1

Notes:

- 1. Refer to Piping Schedule in Section 15052 - Common Work Results for General Piping for service designations.
- 2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
- 3. Contractor may select from options listed.
- 4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by TABLE 1. Required Insulation Thicknesses.
- 5. Insulate all piping systems that are specified to be heat traced.



### 3.04 INSTALLATION

- A. Install insulation and jacket materials in accordance with manufacturer's written instructions.
- B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.
- C. Butt longitudinal and circumferential insulation joints firmly together.
- D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.
- E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.
- F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.
- G. Fittings:
  - 1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
  - 2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
  - 3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.
- H. Valves:
  - 1. Insulate valves 3 inches in nominal size and larger with removable insulating blankets.
  - 2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.
- I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.
- J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.
- K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.
- L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.
- M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.



- N. Thermally isolate all insulation closure locations (end caps, transitions, etc.) Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.
- O. Apply piping identification on jackets as specified in Section 15076 - Pipe Identification.

END OF SECTION





## SECTION 15110

### COMMON WORK RESULTS FOR VALVES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Basic requirements for valves.

##### 1.02 REFERENCES

- A. American Water Works Association (AWWA):
  - 1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.
- B. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
  - 2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
  - 3. A536 - Standard Specification for Ductile Iron Castings.
- C. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.
- D. Society for Protective Coatings (SSPC):
  - 1. SP7 - Brush-Off Blast Cleaning.
  - 2. SP10 - Near-White Blast Cleaning.

##### 1.03 DESIGN REQUIREMENTS

- A. Pressure rating:
  - 1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
  - 2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.
- B. Valve to piping connections:
  - 1. Valves 3 inches nominal size and larger: Flanged ends.
  - 2. Valves less than 3 inches nominal size: Screwed ends.
  - 3. Plastic valves in plastic piping:
    - a. Up to 2.5 inches: Provide solvent or heat welded unions.
    - b. 3 inches and above: Provide solvent or heat-welded flanges.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.



- B. Product data:
1. Submit the following information for each valve:
    - a. Valve type, size, pressure rating, Cv factor.
    - b. Coatings.
    - c. Power valve actuators:
      - 1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
      - 2) Complete wiring diagrams and control system schematics.
    - d. Manual valve actuators:
      - 1) Information on valve actuator including size, manufacturer, model number.
    - e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
    - f. Certifications of reference standard compliance:
      - 1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
    - g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
    - h. Factory test data.
- C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.
1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.
- D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
- E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

## **1.05 QUALITY ASSURANCE**

- A. Manufacturer qualifications:
1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

## **1.06 DELIVERY STORAGE AND HANDLING**

- A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

# **PART 2 PRODUCTS**

## **2.01 MATERIALS**

- A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.



- B. Valve and operator bolts and nuts:
  - 1. Fabricated of stainless steel for the following installation conditions:
    - a. Submerged in sewage or water.
    - b. In an enclosed space above sewage or water.
    - c. In structures containing sewage or water, below top of walls.
    - d. At openings in concrete or metal decks.
  - 2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
  - 3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.
- C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.
- D. Valve bodies: Cast iron in accordance with ASTM A126, Class 30 minimum or ductile iron in accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

## **2.02 INTERIOR PROTECTIVE LINING**

- A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.
- B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.
- C. Lining types:
  - 1. Fusion bonded epoxy:
    - a. Manufacturers: The following or equal:
      - 1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
    - b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
    - c. Apply in accordance with manufacturer's published instructions.
    - d. Lining thickness: 0.010 to 0.012-inch, except that:
      - 1) Lining thickness in grooves for gaskets: 0.005-inch.
      - 2) Do not coat seat grooves in valves with bonded seat.
    - e. Quality control:
      - 1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
      - 2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
      - 3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
      - 4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
      - 5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.



2. High solids epoxy:
  - a. Product equivalent to high solids epoxy specified in Section 09960 - High-Performance Coatings.
    - 1) Certified in accordance with NSF 61 for drinking water use.
    - 2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy coating specified in Section 09960 - High-Performance Coatings.
  - b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
  - c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
    - 1) Repair holidays and other irregularities and retest coating.
    - 2) Repeat procedure until holidays and other irregularities are corrected.

## **2.03 UNDERGROUND VALVES**

- A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.
- B. Coating and wrapping:
  1. Prior to installation, coat buried valves with 2 coats of protective coal tar as specified in Section 09960 - High-Performance Coatings.
  2. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15211 - Ductile Iron Pipe: AWWA C151.
    - a. Ascertain that polyethylene wrapping does not affect operation of valve.

## **2.04 STEAM VALVES**

- A. Valves in steam or steam condensate piping: Ductile iron body in accordance with ASTM A536, Grade 65-45-12 minimum or cast steel or forged steel.

## **2.05 VALVE BOXES**

- A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.
- B. Do not support boxes on valve, valve operator, or pipe.
- C. Boxes:
  1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
  2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.
- D. Manufacturers: One of the following or equal:
  1. Tyler Pipe Industries, Inc.
  2. Neenah Foundry Co.





## **2.06 VALVE OPERATORS**

- A. Valve operator "Open" direction: Open counterclockwise.
- B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels.
- C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
  - 1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
  - 2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.
- D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
  - 1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
  - 2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.
- E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Preparation prior to installation:
  - 1. Install valves after the required submittal on installation has been accepted.
  - 2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.
- B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

### **3.02 INSTALLATION**

- A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.
- B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
  - 1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.



2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.
- C. Install valves with their stems in vertical position above the pipe, except as follows:
  1. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
  2. Install buried plug valves with geared operators with their stems in a horizontal position.
- D. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.
- E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.
- F. Valves with threaded connections:
  1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
  2. Apply pipe joint compound or Teflon tape on external (male) threads to prevent forcing compound into valve seat area.
- G. Valves with flanged connections:
  1. Align flanges and gasket carefully before tightening flange bolts.
  2. When flanges are aligned, install bolts and hand tighten.
  3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.
- H. Valves with soldered connections:
  1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
  2. Position valves in full open position before starting soldering procedure.
  3. Apply heat to piping rather than to valve body.

### **3.03 FIELD APPLIED COATING OF VALVE EXTERIOR**

- A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
  1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
  2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.



### 3.04 COMMISSIONING

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services from each manufacturer for all valves supplied:
  - 1. Provide Manufacturer's Certificate of Source Testing.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
- C. As specified elsewhere for specific valve types, sizes or actuators.
  - 1. Source testing.
  - 2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION





## **SECTION 15114**

### **CHECK VALVES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Check valves.
- B. As specified in Section 15110 - Common Work Results for Valves.

##### **1.02 REFERENCES**

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Inch Standard.
- B. American Water Works Association (AWWA):
  - 1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.
- C. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
  - 2. A313 - Standard Specification for Stainless Steel Spring Wire.
  - 3. A536 - Standard Specification for Ductile Iron Castings.
  - 4. B582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
  - 5. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

##### **1.03 SYSTEM DESCRIPTION**

- A. Design requirements:
  - 1. Check valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
    - a. In either horizontal or vertical position.
    - b. Suitable for service working pressures up to 150 pounds per square inch gauge.

##### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15110 - Common Work Results for Valves.



- C. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

## **1.05 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 SWING CHECK VALVES**

- A. Valves 1/4-inch through 3 inches:
  - 1. Manufacturers: One of the following or equal:
    - a. Crane Valve Co., Number 36.
    - b. Lunkenheimer Co., Figure 554Y.
  - 2. Valve design:
    - a. Threaded joints.
    - b. Y-pattern body with integral seat.
    - c. Hinged disc.
    - d. Access to valve seat for regrinding without disassembly of piping.
  - 3. Materials:
    - a. Body, cap, hinge, and disc: Bronze.
- B. Valves 4 inches through 24 inches:
  - 1. Manufacturers: One of the following or equal:
    - a. Kennedy, Figure 106LW or M&H, Model 159.
    - b. Mueller Co., Model A-2600.
    - c. APCO Model 250.
    - d. Crispin SWL Series.
  - 2. Valve design:
    - a. In accordance with AWWA C508.
    - b. Constructed to permit top entry and removal of internal components without removing the valve.
    - c. Equipped with outside lever and weight.
  - 3. Materials:
    - a. Body:
      - 1) Digester Mixing: Cast iron, ASTM A126 Class B or ASTM A536 Grade 65-45-12 Ductile Iron.
      - 2) FOG service: Stainless steel.
    - b. Disc:
      - 1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze. FOG service to be stainless steel.
      - 2) 4-inch valves: Bronze or stainless steel rings and seats. FOG service to be stainless steel.
      - 3) 6 inches and larger valves: Bronze-faced or stainless steel rings and seats. FOG service to be stainless steel.
      - 4) Seat:
        - a) Fluid: Water
          - (1) EPDM.
        - b) Fluid: FOG
          - (1) Buna N.



- c. Hinge pins: Stainless steel.

## **2.02 DUCKBILL CHECK VALVES**

- A. Manufacturers: One of the following or equal:
  - 1. Tide Flex, Series TF-1.
- B. Design:
  - 1. When line pressure inside the valve exceeds the backpressure outside the valve, the line pressure forces the bill of the valve to open, allowing flow to pass. When backpressure exceeds the line pressure, the bill of the valve is forced closed preventing backflow.
  - 2. Maximum downstream head: 17 feet.
  - 3. Cracking pressure, 1 to 2 inches w.c.
  - 4. Flat bottom, flared top.
- C. End connection:
  - 1. Flanged.
- D. Materials of construction:
  - 1. Single piece elastomer construction with internal polyester fabric reinforcing all vulcanized into a composite material.
    - a. Internal reinforcing sufficient to maintain structural integrity under the specified operating conditions.
    - b. Exterior applications require coating for UV protection and to resist pest gnawing.
  - 2. Elastomeric material: Buna-N.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install valves as specified in Section 15110 and the manufacturer's instructions.

### **3.02 FIELD APPLIED COATING OF VALVE EXTERIOR**

- A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
  - 1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
  - 2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.



03

## COMMISSIONING

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
  - 1. Valves:
    - a. Test witnessing: Witnessed.
    - b. Conduct pressure and leak test, as specified in Section 15956 - Piping Systems Testing.

END OF SECTION





## **SECTION 15116**

### **PLUG VALVES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Non-lubricated plug valves.
  - 2. Lubricated plug valves.
  - 3. Multi-port plug valves.
  - 4. Multi-port plug valves for digester gas service shall be as specified in Section 11381 - Digester Appurtenances.

##### **1.02 REFERENCES**

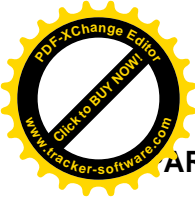
- A. American Water Works Association (AWWA):
  - 1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
  - 2. C606 - Grooved and Shouldered Joints.
- B. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
  - 2. A536 - Standard Specification for Ductile Iron Castings.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures and 15110 - Common Work Results for Valves.
- B. Product data.
- C. Shop drawings.
- D. Calculations.
- E. Vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.
- F. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning:
    - a. Interior coating.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

##### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.



## ART 2 PRODUCTS

### 2.01 GENERAL

- A. As specified in Section 15110 - Common Work Results for Valves.

### 2.02 NON-LUBRICATED PLUG VALVES

- A. Manufacturers: One of the following or equal:
1. DeZurik, "PEC".
  2. Clow Valve.
- B. Design:
1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
  2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
    - a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
    - b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
    - c. Valves in FOG service: Resilient material suitable for abrasive stream and petroleum or digester gas at continuous duty at 180 degrees Fahrenheit. Stream with pH of 2 to 8 standard units.
  3. Compression washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
  4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
  5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
  6. Clearly mark valves to indicate their open and closed positions.
  7. Provide valves with ends as required by piping details indicated on the Drawings.
    - a. Grooved end body valves:
      - 1) Usage: Plug valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints and as indicated on the Drawings.
      - 2) Grooved end joint design: In accordance with AWWA C606.
- C. Materials:
1. Body and plug: ASTM A126, Class B, cast-iron with plug face of Buna N or other manufacturer-recommended material suitable for the intended service as specified under paragraph "Design" above.
  2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8-inch on surfaces contacting the plug face.
  3. Stem bearing and bottom bearing: Type 316 stainless steel
  4. Internal parts, except the body and plug: Type 316 stainless steel
  5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.



## **2.03 LUBRICATED PLUG VALVES**

- A. Manufacturers: One of the following or equal:
  - 1. Nordstrom.
  - 2. Walworth.
- B. Type: Semi-steel tapered plug valves.
- C. Design:
  - 1. Plug removable through top of valve.
  - 2. Combined lubricant screw and grease gun fitting, of the type where the pressure of the grease can be used to raise the plug slightly off its seat.
- D. Where indicated on the Drawings or specified, provide plug valves with high head extension and floor stand with indicator. Provide worm gear-operated valves with worm shaft extension and floor stand, and with indicator supplied by manufacturer of plug valve:
  - 1. Equip floor stands serving plug valves with individual operating wrenches.

## **2.04 VALVE OPERATORS**

- A. Furnish valves with an operating wrench or worm gear operator:
  - 1. Equip valves 4 inch nominal size and smaller with a lever operator.
  - 2. Equip valves 6 inch nominal size and larger with a worm gear operator.

## **2.05 COATING**

- A. Coat and test interior metal surfaces as specified in Section 15110 - Common Work Results for Valves.
- B. Coat exterior metal surfaces as specified in Section 09960 – High Performance Coatings.
- C. Field applied coating of valve exterior:
  - 1. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
    - a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
    - b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

## **2.06 SHIPMENT, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS**

- A. As specified in Section 01600 - Product Requirements.



## **ART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install valves as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.
  - 1. Unless differently indicated on the Drawings install valves as follows:
    - a. For installation in horizontal pipes, install the valve with flow against face of plug. Install the valve laying on its side so plug rotates 90-deg to open. In the open position, the plug is located in the top half of the valve body.
    - b. For installation in vertical pipes, install the valve with seat at the top.
- B. For valves requiring lubrication: Lubricate and fill extended lubricant pipes with lubricant suitable for service intended.

### **3.02 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
  - 1. Valves:
    - a. Test witnessing: Witnessed.
    - b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION



## SECTION 15117

### SPECIALTY VALVES

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Specialty valves.
- B. As specified in Section 15110 - Common Work Results for Valves.

##### **1.02 REFERENCES**

- A. American Society of Civil Engineers (ASCE):
  - 1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.
- B. American Society of Mechanical Engineers (ASME):
  - 1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.
- C. American Water Works Association (AWWA):
  - 1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
  - 2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).
- D. ASTM International (ASTM):
  - 1. A48 - Standard Specification for Gray Iron Castings.
  - 2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
  - 3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
  - 4. A536 - Standard Specification for Ductile Iron Castings.
  - 5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.
  - 6. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
- E. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

##### **1.03 DEFINITIONS**

- A. NEMA Type 4 enclosure in accordance with NEMA 250.

##### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15110 - Common Work Results for Valves.



- C. Commissioning submittals:
  - 1. Backflow preventer certification.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

## **1.05 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 RESERVOIR (ALTITUDE) CONTROL VALVES**

### **2.02 FLOAT VALVES**

- A. Manufacturers: One of the following or equal:
  - 1. Cla-Val Co., Number 124.
  - 2. GA Industries, Figure 5560.
- B. Float valves: Pilot controlled, diaphragm, or piston actuated from hydraulic pressure of liquid flowing through valve.
- C. Design:
  - 1. Valves: Single seated. Open wide when the float is at low level, and close driptight at high level.
  - 2. Float level: Adjustable in the field.

### **2.03 HYDROSTATIC PRESSURE RELIEF VALVES**

- A. Flap gate type:
  - 1. Manufacturers: One of the following or equal:
    - a. Clow Corp.
    - b. Neenah Foundry Co.
  - 2. Design:
    - a. Provide valves with vertical seat design and offset single pivoted hinge.
    - b. Valve components: Flap gate, body with flanged end, hinge pin, and gate seat ring.
    - c. Design valve so that flap gate begins to open at a head of 1/3 the inner diameter of the valve body.
    - d. Cement and mechanically retain gate seat ring in place.
  - 3. Materials:
    - a. Flap gate and body: Cast iron in accordance with ASTM A126 Class B or bronze in accordance with ASTM B584 UNS Number C84400.
    - b. Hinge pin: Bronze of the type specified in the preceding subparagraph or stainless steel in accordance with ASTM A276 Type 304.
    - c. Gate seat ring: EPDM.
- B. Pop-up type:
  - 1. Manufacturers: One of the following or equal:
    - a. Clow Corp.
    - b. Neenah Foundry Co.



2. Design:
  - a. Design valve to begin opening at a maximum head of 9 inches.
  - b. Integrally cast locking lugs into body.
    - 1) Prevent groundwater pressure from separating the cover and strainer from the body.
  - c. The cover and the strainer shall be easily removed by release from the locking lugs.
  - d. Provide bronze seats pressed and sealed into grooves on the top of body and Buna-N seal on the underside of cover.
    - 1) Machine seats to form bronze -to- Buna-N contact when the cover is in closed position.
3. Materials:
  - a. Cover, body, and strainer: Cast-iron in accordance with ASTM A126, Class B.

## **2.04 PUMP CONTROL VALVES**

- A. Manufacturers: One of the following or equal:
  1. Cla-Val Co., Model 60-11.
  2. GA Industries, Inc., Model 1730-D.
- B. Operation:
  1. Opening and closing rates: Adjustable over a minimum range of 30 seconds to 2 minutes.
  2. Suitable at rated working pressure of 250 psi.
  3. Function as a check valve during power failure.
- C. Design:
  1. Pilot valve strainer.
  2. Adjustable pilot valve with stainless steel trim.
  3. Flanged ends.
  4. Valve position indicator.
  5. Solenoid valve: 120 volts alternating current, Class F coil, NEMA Type 4X enclosure.
  6. Limit switch: 120 volts alternating current, NEMA Type 4X enclosure.
- D. Materials:
  1. Valve body: Cast or ductile iron.
  2. Body trim: Bronze.
  3. Diaphragm: EPDM.

## **2.05 SOLENOID VALVES**

- A. 2-way solenoid valves:
  1. Manufacturers: One of the following or equal:
    - a. Automatic Switch Co., Series 8210.
    - b. Skinner Electric Valve Division, Series C.
- B. 3-way solenoid valves:
  1. Manufacturers: One of the following or equal:
    - a. Automatic Switch Co., Series 8320.
    - b. Skinner Electric Valve Division, Type A4.



- C. 4-way solenoid valves:
  - 1. Manufacturers: One of the following or equal:
    - a. Automatic Switch Co., Bulletin 8344.
    - b. Skinner Electric Valve Division, Series V9.
- D. Design:
  - 1. Valves: Suitable for service under the following conditions:
    - a. Fluid: Water.
    - b. Temperature of fluid: 35-180 degrees Fahrenheit.
    - c. Piping test pressure: 150 pounds per square inch gauge.
  - 2. Unless otherwise indicated on the Drawings, provide valves that meet the following requirements:
    - a. Minimum NEMA Type 4 enclosure.
    - b. 120 VAC operation.
    - c. Suitable for use as indicated on the Drawings.
    - d. Minimum Class F coil insulation.
  - 3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
  - 4. Furnish with manual/bypass operators.
- E. Materials:
  - 1. Body: Brass or bronze.
  - 2. Seats: Resilient material.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install as specified in Section 15110 - Common Work Results for Valves in accordance with manufacturer's published instructions.
- B. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.

### **3.02 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
  - 2. Manufacturer's Representative onsite requirements:
    - a. Installation: 1 trip, 1 day minimum.
    - b. Functional Testing: 1 trips, 1 day minimum each.
    - c. Training:
      - 1) Maintenance: 2 hours per session, 2 sessions.
      - 2) Operations: 2 hours per session, 2 sessions.

END OF SECTION





## **SECTION 15119**

### **AIR AND VACUUM RELIEF VALVES**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Air release valves, air and vacuum valves, and air vents.
- B. As specified in Section 15110 - Common Work Results for Valves.

##### **1.02 REFERENCES**

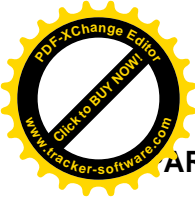
- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  - 2. B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
- B. American Water Works Association (AWWA).
- C. ASTM International (ASTM):
  - 1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
  - 2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
  - 3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
  - 4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15110 - Common Work Results for Valves.
- C. Commissioning submittals:
  - 1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

##### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bond.



## **ART 2 PRODUCTS**

### **2.01 AIR RELEASE VALVES, WATER SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Valve and Primer Corp., DeZURIK/APCO Series 200.
  - 2. Multiplex Manufacturing Co., Crispin PL Series.
- B. Design:
  - 1. Pressure rating: 150 pounds per square inch gauge.
  - 2. Inlet: Screwed, 2-inch.
  - 3. Orifice size: 1/4-inch diameter.
- C. Materials:
  - 1. Valve body: Cast iron.
  - 2. Float and internal trim: Type 316 stainless steel.
  - 3. Seat or valve plunger: Buna-N.

### **2.02 AUTOMATIC AIR VENTS, HOT WATER SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. ITT-Bell and Gossett, Number 87.
  - 2. Hoffman Specialty Manufacturing Corp., Number 78.

### **2.03 AIR RELEASE VALVES, SEWAGE SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Valve and Primer Corp., DeZURIK/APCO, Series 400.
  - 2. Multiplex Manufacturing Co., Crispin Series S.
- B. Design:
  - 1. Operation: Release accumulated air in sewage pipelines operating under pressure. After entrained air escapes through the orifice, the orifice is plugged by a needle mounted on a compound lever mechanism.
  - 2. Internal components removable through top cover without removing valve from pipeline.
  - 3. Pressure rating: 150 pounds per square inch.
  - 4. Orifice size: 1/4-inch diameter.
  - 5. Connections: Threaded, 2-inch diameter inlet and threaded, 1/2-inch diameter outlet.
- C. Accessories:
  - 1. Inlet shutoff valve. Utilize eccentric plug valve.
  - 2. 2 blowoff valves for backflushing.
  - 3. 10 feet of hose with quick disconnect couplings.
- D. Materials:
  - 1. Body: Cast iron.
  - 2. Float: Type 316 stainless steel.
  - 3. Needle: Buna-N.



## **2.04 AIR AND VACUUM VALVES, SEWAGE SERVICE**

- A. Float activated air and vacuum release valves:
  - 1. Manufacturers: One of the following or equal:
    - a. Multiplex Manufacturing Co., Crispin SA Series.
    - b. Valve and Primer Corp., DeZURIK/APCO, Series 401.
  - 2. Design:
    - a. Operation: Release air from pipeline as pipeline is filled and allow air to enter pipeline as pipeline is drained.
    - b. Internal components removable through top cover without removing valve from pipeline.
    - c. Pressure rating: 150 pounds per square inch.
  - 3. Accessories:
    - a. Inlet shutoff valve. Utilize eccentric plug valve.
    - b. 2 blowoff valves for backflushing.
    - c. 10 feet of hose with quick disconnect couplings.
  - 4. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
  - 5. Materials:
    - a. Body: Cast iron.
    - b. Float: Type 316 stainless steel.
    - c. Seat: Buna-N.

## **2.05 COMBINATION AIR VALVES - SEWAGE SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Valve and Primer Corp., DeZURIK/APCO, Series 440.
  - 2. Multiplex Manufacturing Co., Crispin Series US.
- B. Design:
  - 1. Operation: Automatic exhaust and intake of large quantities of air during filling and draining of pipelines, respectively, and release of accumulated air while pipeline is under pressure.
  - 2. Design: Utilize compound lever system in conjunction with large and small orifices.
  - 3. Internal parts removable through top cover without removing valve from pipeline.
  - 4. Pressure rating: 150 pounds per square inch.
  - 5. Connections: 2-inch threaded inlet and 1-inch threaded outlet.
  - 6. Accessories:
    - a. Inlet shutoff valve.
    - b. 2 blowoff valves for backflushing.
    - c. 10 feet of hose with quick disconnect couplings.
- C. Materials:
  - 1. Body: Cast iron.
  - 2. Float: Type 316 stainless steel.
  - 3. Needle: Buna-N.



## **ART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install as specified in Section 15110 - Common Work Results for Valves and manufacturer's instructions.
- B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

### **3.02 FIELD APPLIED COATING OF VALVE EXTERIOR**

- A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coating.
  - 1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the manufacturer.
  - 2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, remove existing coating by abrasive blast cleaning and apply the coating system used for coating adjacent piping in accordance with Section 09960 - High-Performance Coating.
    - a. Submerged valves: SP-5 White Metal Blast cleaning.
    - b. Other valves: SP-10 Near-white blast cleaning.

### **3.03 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Provide certificates:
    - a. Manufacturer's Certificate of Installation and Functionality Compliance.
- C. Functional testing:
  - 1. Valves:
    - a. Test witnessing: Witnessed.
    - b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

**END OF SECTION**



## SECTION 15120

### PIPING SPECIALTIES

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Piping specialties including:
  - 1. Flexible rubber connections.
  - 2. Bellows type expansion joints.
  - 3. Vibration control joints.
  - 4. Transition fittings.
  - 5. Pipe saddles.
  - 6. Tapping sleeves.
  - 7. Spray nozzles.

##### **1.02 REFERENCES**

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
- B. American Water Works Association (AWWA):
  - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
  - 2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
- C. ASTM International (ASTM):
  - 1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
  - 2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
  - 4. A536 - Standard Specification for Ductile Iron Castings.
- D. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
  - 2. 372 - Drinking Water System Components - Lead Content.

##### **1.03 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. For each piping product in this Section as applicable:
    - a. Design features.
    - b. Load capacities.
    - c. Material designations by UNS alloy number or ASTM Specification and Grade.
    - d. Data needed to verify compliance with the Specifications.



- e. Catalog data.
  - f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
- C. Calculations:
- 1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.
- D. Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning:
- 1. Provide as specified in this Section.

#### **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

### **PART 2 PRODUCTS**

#### **2.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements.
- B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

#### **2.02 FLEXIBLE RUBBER CONNECTIONS**

- A. Manufacturers: One of the following or equal:
- 1. Mercer Rubber Co., Type 150 Vibraflex.
  - 2. Red Valve Co., Inc., Part Number P-5.
- B. Provide flexible rubber connections with 3/8 inch thick EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.
- C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

#### **2.03 BELLOWS TYPE EXPANSION JOINTS**

- A. Expansion joints for general service:
- 1. Expansion joints: Flexible bellows type, or as otherwise specified or indicated on the Drawings.
  - 2. Manufacturers:
    - a. Expansion joints: One of the following or equal:
      - 1) Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
      - 2) Flex-Weld, Inc., Keflex, Series 308.
      - 3) Victaulic, Depend-o-Lok, Omniflex stainless bellows expansion joint.
    - b. Pipe alignment guides: One of the following or equal:
      - 1) Senior Flexonics Pathway, Inc.
      - 2) Flex-Weld, Inc.



- c. Intermediate supports: Provide with protective saddles. One of the following or equal:
  - 1) Unistrut Corporation, Roller-type.
  - 2) Bergen-Paterson Pipe Support Corp.
- 3. Design:
  - a. Expansion joint rating: 150 pounds per square inch gauge, at 300 degrees Fahrenheit.
  - b. Bellows: Multi-ply (3 ply minimum) stainless steel, equipped with a self-draining liner guide.
  - c. Axial travel of expansion joints: Not less than 1.50 inches.
  - d. Ends: 150 pound ASME flanges, Victaulic, Depend-o-Lok Airmaster/Fluidmaster coupled ends, or plain suitable for welding connections, as required for piping in which installed.

- B. Expansion joints for steam and hot water:
  - 1. Manufacturers: One of the following or equal:
    - a. Flex-Weld, Inc., Keflex, Series 308-1215.
    - b. Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
    - c. Victaulic, Depend-o-Lok Omniflex Expansion Joint.
  - 2. Design:
    - a. Single reinforced bellows type or Victaulic mechanical couplings.
    - b. Pressure and temperature ratings: 150 pounds per square inch gauge, and 500 degrees Fahrenheit service.
    - c. Bellows: Multi-ply (3 ply minimum) Type 321 stainless steel, equipped with a Type 321 stainless steel liner.
    - d. Axial travel of expansion joints: 3 inches minimum.
    - e. Ends: 150 pound ASME flanges.

## **2.04 SLIP TYPE EXPANSION JOINTS**

- A. Expansion joints for steam cleaned piping:
  - 1. Manufacturers: One of the following or equal:
    - a. Smith-Blair, Inc., Number 612 with slip pipe and without limit rods.
    - b. Dresser Industries, Inc., Style 63, Type 2.
  - 2. Line and coat slip pipe and interior of body with fusion-bonded epoxy of minimum 0.012-inch thickness.
  - 3. Packing: Suitable for temperatures greater than 212 degrees Fahrenheit.
- B. PVC expansion joints:
  - 1. Flexible bellows type.
  - 2. Manufacturers: One of the following or equal:
    - a. NDS Flow Management, Quik-Fix.
    - b. Chemtrol.
  - 3. Materials: PVC with EPDM o-ring.
  - 4. Design:
    - a. 150 pound per square inch pressure rating.
    - b. Double o-ring seal.
    - c. Axial travel: Not less than 1.5 inches.
    - d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.



## **2.05 VIBRATION CONTROL JOINTS**

- A. Manufacturers:
  - 1. Braided bronze flexible vibration joints 2 inches and less in size: One of the following or equal:
    - a. Senior Flexonics Canada, Inc., Type BRC bronze connectors.
    - b. Flex-Weld, Inc., Keflex, Type KFCB.
  - 2. Flexible vibration joints larger than 2 inches: One of the following or equal:
    - a. Senior Flexonics Canada, Inc., Type TCS.
    - b. Flex-Weld, Inc., Keflex, Series 151-TR-1215.
  - 3. Corrugated stainless steel with stainless steel braid flexible vibration joints: One of the following or equal:
    - a. Senior Flexonics Canada, Inc., Type BSFS stainless steel connectors.
    - b. Flex-Weld, Inc., Keflex, Type USFNSS-31.
- B. Design:
  - 1. Flexible vibration joints 2 inches and smaller: Braided bronze, suitable for pressures of not less than 250 pounds per square inch gauge.
  - 2. Flexible vibration joints larger than 2 inches: Flexible bellows type, suitable for pressures of not less than 150 pounds per square inch gauge, at 70 degrees Fahrenheit, except as follows:
    - a. Provide vibration joints in piping subject to test pressures higher than 150 pounds per square inch gauge, suitable for such higher pressures.
    - b. Bellows: Stainless steel, equipped with a stainless steel liner.
    - c. Ends: ASME Class 150 flanges.
  - 3. Vibration joints in high-pressure air piping and in digester gas piping: Corrugated Type 316 stainless steel with stainless steel braid, suitable for pressures of not less than 150 pounds per square inch gauge.
    - a. Ends: ASME Class 150 flanges.
- C. Protection: Protect vibration absorbers against end loading and torsional stresses by anchoring attached piping.

## **2.06 TRANSITION FITTINGS**

- A. Manufacturers: One of the following or equal:
  - 1. Spears.
- B. Materials:
  - 1. Slip socket: Schedule 80 PVC.
  - 2. Collar: Type 316 stainless steel.
  - 3. Threaded insert: Type 316 stainless steel or as appropriate for piped fluid.

## **2.07 PIPE SADDLES**

- A. Manufacturers: One of the following or equal:
  - 1. Smith-Blair, Inc., Style 317.
  - 2. Romac Industries, Inc., Style 202S.
- B. Materials:
  - 1. Pipe saddles: Ductile iron.
  - 2. Straps, bolts, and nuts: Type 304 stainless steel with Teflon coating on nuts.
  - 3. Gaskets: Rubber.





## **2.08 TAPPING SLEEVES**

- A. Manufacturers: One of the following or equal:
  - 1. Smith-Blair, Inc., Style 622.
  - 2. Romac Industries, Inc., Style FTS 420.
- B. Materials:
  - 1. Tapping sleeves: Steel construction.
  - 2. Bolts and nuts: Type 304 stainless steel.
  - 3. Nuts: Teflon coated.
  - 4. Gaskets: Rubber
  - 5. Size of tapped boss: As indicated on the Drawings.

## **2.09 SPRAY NOZZLES**

- A. Design:
  - 1. Operating pressure 10 pounds per square inch gauge, at which pressure each nozzle discharges not less than 3.5 gallons per minute, nor more than 5.0 gallons per minute.
    - a. Spray: Flat, heavy sheet, fan with uniform distribution.
    - b. Fan width at the water surface not less than 6.5 feet at 10 pounds per square inch gauge.
    - c. Spray deflection with a replaceable deflector insert free to rotate away from the orifice opening and mechanically locked in place and counterweighted.
  - 2. Spray nozzles structurally suitable for pressure up to 200 pounds per square inch gauge.
  - 3. Nozzles, easy flush type.
- B. Materials:
  - 1. Spray nozzles: Lead bronze.
  - 2. Nozzles provided with 1/4 inch national pipe thread, and the orifice diameter not less than 1/4 inch.
  - 3. Replaceable spray deflector: Neoprene rubber.

## **2.10 SHIPPING**

- A. As specified in Section 01600 - Product Requirements.

# **PART 3 EXECUTION**

## **3.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements.
- B. Drawings supersede conflicts with this Section.
- C. Bellows type expansion joints and vibration control joints:
  - 1. Protect joints against damage during pressure test.



## 02 INSTALLATION

- A. Expansion control joints:
  - 1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
  - 2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
  - 3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
    - a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
  - 4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
  - 5. Provide control rods and additional guides where indicated on the Drawings, but at no greater intervals than recommended by the joint manufacturer in published instructions.
  - 6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.
- B. Expansion joints for steam cleaned piping:
  - 1. Install no less than 1 expansion joint in a run of steam cleaned piping which exceeds 20 feet in length.
    - a. Do not exceed 200 feet in spacing of expansion joints.
  - 2. Install expansion joints in steam cleaned piping between anchors.
- C. Steam connections for steam cleaned piping:
  - 1. Provide connections for steam service in steam cleaned piping where indicated on the Drawings.
  - 2. Locate connections for steam near an anchor and away from an expansion joint.
- D. Bellows type expansion joints for steam and hot water:
  - 1. Install not less than 1 expansion joint in a run of steam or hot water piping which exceeds 20 feet in length.
    - a. Do not exceed 150 feet spacing of expansion for steam piping and 200 feet for hot water piping.
  - 2. Where possible, install expansion joints adjacent to an anchor; provide piping with 2 concentric guides, the first being within 2 feet of the end of the joint opposite the anchor.
  - 3. At expansion joints not installed adjacent to an anchor, provide 2 concentric guides on piping within 2 feet off both ends of the expansion joint.
  - 4. Lock expansion joint against movement until pressure test is completed.
- E. Vibration control joints:
  - 1. Install vibration control joints at piping connections to or from mechanical equipment to prevent transmitting equipment vibration through the piping system.
- F. Transition couplings:
  - 1. Application:



- a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
- 2. Install transition-coupling products specifically designed and manufactured for that application.
- G. Pipe saddles:
  - 1. Coat threads on bolts with anti-gall coating prior to installation.
- H. Tapping sleeves:
  - 1. Verify existing pipe material and outer diameter prior to ordering materials.
  - 2. Coat threads on bolts with anti-gall coating prior to installation.
  - 3. Install gate valve between surge cushion and piping.
- I. Spray nozzles:
  - 1. Install spray nozzles so that elevation of the nozzles is 18 inches above the water surface.

### **3.03 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning and this Section.
- B. Manufacturer services:
  - 1. Required only for:
    - a. Transition couplings.
    - b. Tapping sleeves for large diameter pipe.
  - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
  - 3. Provide Manufacturer's Representative Onsite:
    - a. Installation: 2 trip / 1 day each:
      - 1) Installation consultation and advice.
      - 2) Installation inspection.
- C. Field testing:
  - 1. As specified in Section 15052 - Common Work Results for General Piping.
  - 2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION





## SECTION 15121

### PIPE COUPLINGS - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Pipe couplings for ductile iron piping.
  - 2. Pipe couplings for carbon steel piping.
  - 3. Pipe couplings for stainless steel piping.

##### 1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. American Society of Mechanical Engineers (ASME):
  - 1. B31.1 - Power Piping.
  - 2. B31.9 - Building Services Piping.
- C. American Water Works Association (AWWA):
  - 1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - 2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
  - 3. C606 - Standard for Grooved and Shouldered Joints.
- D. ASTM International (ASTM):
  - 1. A36 - Standard Specification for Carbon Structural Steel.
  - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
  - 3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
  - 4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
  - 5. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
  - 6. A536 - Standard Specification for Ductile Iron Castings.
  - 7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
  - 8. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
  - 9. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
  - 10. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- E. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.
  - 2. 372 - Drinking Water System Components - Lead Content.



1.03

## **SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data:
  - 1. For each product in this Section as applicable:
    - a. Design features.
    - b. Load capacities.
    - c. Material designations by UNS alloy number or ASTM Specification and Grade.
    - d. Data needed to verify compliance with the Specifications.
    - e. Catalog data.
    - f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
- C. Calculations:
  - 1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

## **1.04 WARRANTY**

- A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

- A. As specified in Section 01600 - Product Requirements:
  - 1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.
- B. Known acceptable manufacturers are listed by specific products.
- C. Provide references as specified in this Section by specific product.
- D. Manufacturer's representatives requirements as specified in Section 01756 - Commissioning and this Section by specific product.
- E. Gaskets for flexible couplings and flanged coupling adapters:
  - 1. Provide gasket materials for piping applications as follows:
    - a. Low-pressure and high-pressure air, steam, hot water: EPDM.
    - b. All other piping applications: Neoprene rubber or Buna-N
- F. Exterior coatings for underground and submerged applications:
  - 1. Manufacturers: One of the following or equal:
    - a. Tapecoat Co., Inc., T.C. Mastic.
    - b. Kop-Coat Co., Inc., Bitumastic Number 50.
  - 2. Thickness: Minimum 0.040 inch.



## 2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

- A. Dismantling joints:
  - 1. Manufacturers: One of the following or equal:
    - a. Romac Ind., Inc., Style DJ400.
    - b. Smith-Blair, Inc., Series 975.
  - 2. Materials:
    - a. Flanged spool: AWWA C207 steel pipe:
      - 1) ASTM A53 for sizes 3 inches to 12 inches.
      - 2) ASTM A36 for sizes 14 inches to 72 inches.
    - b. End ring and body:
      - 1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
      - 2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36 or A53.
    - c. Follower ring: Ductile iron in accordance with ASTM A536.
    - d. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
    - e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.
  - 3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
  - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- B. Flanged coupling adapters: 12-inch size and smaller:
  - 1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 227.
    - b. Romac Ind., Inc., Style FCA501.
    - c. Smith-Blair, Inc., Series 912.
  - 2. Materials:
    - a. Flanged body: Ductile iron in accordance with ASTM A536.
    - b. Follower ring: Ductile iron in accordance with ASTM A536.
    - c. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  - 3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  - 4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- C. Flanged coupling adapters: Greater than 12-inch size:
  - 1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 128-W.
    - b. Romac Ind., Inc., Style FC400.
    - c. Smith-Blair, Inc., Series 913.



2. Materials:
  - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
  - b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
  - c. Bolts and hex nuts:
    - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
    - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

D. Flexible couplings:

1. Manufacturers: One of the following or equal:
  - a. Dresser, Inc., Style 253.
  - b. Romac Ind., Inc., Style 501.
  - c. Smith-Blair, Inc., Series 441.
2. Materials:
  - a. Center rings: Ductile iron in accordance with ASTM A536.
  - b. Follower rings: Ductile iron in accordance with ASTM A536.
  - c. Bolts and hex nuts:
    - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
    - 2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use steel flexible coupling per Pipe Couplings for Steel Piping

E. Restrained flange coupling adapter:

1. Manufacturers: One of the following or equal:
  - a. Romac Ind., Inc., Style RFCA.
  - b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
  - a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
  - b. Follower ring: Lug type restraint system.
    - 1) Follower ring: Ductile iron in accordance with ASTM A536.
    - 2) Restraining lugs: Ductile iron in accordance with ASTM A536.
      - a) Designed to contact the pipe and apply forces evenly.





- 3) Restraining bolts:
    - a) Ductile iron in accordance with ASTM A536.
    - b) Bolt heads shall be designed to twist off when the proper torque has been applied.
  - c. Bolts and hex nuts:
    - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
    - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
  5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.
- F. Grooved joint couplings:
1. Manufacturers: The following or equal:
    - a. Victaulic Co., Series 31 or equal.
  2. Materials:
    - a. Housings: Ductile iron in accordance with ASTM A536.
    - b. Gasket:
      - 1) BUNA-N.
    - c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
    - d. Coating: As specified in Section 09960 - High-Performance Coatings.
  3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
  4. For connection to IPS steel pipe sizes, Victaulic Style 307.

## **2.03 PIPE COUPLINGS FOR CARBON STEEL PIPING**

- A. Dismantling joints:
1. Manufacturers: One of the following or equal:
    - a. Romac Ind., Inc., Style DJ400.
    - b. Smith-Blair, Inc., Series 975.
  2. Materials:
    - a. Flanged spool:
      - 1) C207 Schedule 40 pipe in accordance with ASTM A53 for sizes 3 inches to 12 inches.
      - 2) Steel for pipe in accordance with ASTM A36 or A53 for sizes 14 inches to 72 inches.
    - b. End ring and body:
      - 1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
      - 2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36.
    - c. Follower ring: Ductile iron in accordance with ASTM A536 or steel in accordance with ASTM A36 or A576.
    - d. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.



- 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
    - e. Tie rods: High tensile steel in accordance with ASTM A193 grade B7.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Fusion bonded epoxy certified in accordance with NSF 61.
- B. Flanged coupling adapters:
  1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 128-W.
    - b. Romac Ind., Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
    - c. Smith-Blair, Inc., Series 913.
  2. Materials:
    - a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - c. Bolts and hex nuts:
      - 1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
  4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
- C. Flexible couplings:
  1. Manufacturers: One of the following or equal:
    - a. Dresser, Inc., Style 38.
    - b. Smith-Blair, Inc., Series 411.
    - c. Romac Ind., Inc., Style 511 or Style 400.
  2. Materials:
    - a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    - b. Bolts and hex nuts:
      - 1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
  3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.



4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Diameter	Sleeve Length
2-1/2 inch and smaller	Manufacturer's standard
3 inch through 6 inch	7 inch
8 inch through 14 inch	7 inch
Greater than 14 inches	10 inch

D. Restrained flange coupling adapters:

1. Manufacturers: One of the following or equal:
  - a. Romac Ind., Inc., Style RFCA.
  - b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
  - a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
  - b. Follower ring: Lug type restraint system.
    - 1) Follower ring: Ductile iron in accordance with ASTM A536.
    - 2) Restraining lugs: Ductile iron in accordance with ASTM A536.
      - a) Designed to contact the pipe and apply forces evenly.
    - 3) Restraining bolts: Ductile iron in accordance with ASTM A536. Bolt heads shall be designed to twist off when the proper torque has been applied.
  - c. Bolts and hex nuts:
    - 1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
    - 2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy certified in accordance with NSF 61.

E. Grooved joint couplings:

1. Model numbers from one manufacturer are shown to indicate type only. Equivalent products of other manufacturers may be submitted for approval.
2. Coating: As specified in Section 09960 - High-Performance Coatings.
3. Sizes through 12 inch:
  - a. Rigid type:
    - 1) Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
    - 2) 2 inch through 6 inch: Installation-ready, for direct stab installation without field disassembly, with grade EHP gasket rated to plus 250 degrees Fahrenheit.
    - 3) Manufacturers: One of the following or equal:
      - a) Victaulic Style 107.
      - b) Victaulic Zero-Flex Style 07.
  - b. Flexible type:
    - 1) For use in locations where vibration attenuation and stress relief are required.



- 2) Three flexible couplings may be used in lieu of a flexible connector.
- 3) The couplings shall be placed in close proximity to the source of the vibration.
- 4) Manufacturers: The following or equal:
  - a) Victaulic Style 77.
- c. Flange adapter:
  - 1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
  - 2) Manufacturers: The following or equal:
    - a) Victaulic Style 741.
4. Sizes 14 inch through 24 inch:
  - a. Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.
  - b. Rigid type:
    - 1) Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
    - 2) Manufacturers: The following or equal:
      - a) Victaulic Style W07.
  - c. Flexible type:
    - 1) Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
    - 2) Manufacturers: The following or equal:
      - a) Victaulic Style W77.
  - d. Flange adapter:
    - 1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
    - 2) Manufacturers: The following or equal:
      - a) Victaulic Style W741.
5. For sizes 30 inch and larger:
  - a. Manufacturers: The following or equal:
    - 1) Victaulic Style AGS multiple-segment housing may be used.

## **2.04 PIPE COUPLINGS FOR STAINLESS STEEL PIPING**

- A. Flexible couplings:
  1. Manufacturers: The following or equal:
    - a. Dresser, Inc., Style 38.
- B. Grooved joint couplings:
  1. Manufacturers: The following or equal:
    - a. Victaulic Co.
  2. Materials:
    - a. Housings:
      - 1) Ductile iron in accordance with ASTM A536.
      - 2) Stainless steel in accordance with ASTM A351.
    - b. Gasket: Elastomer in accordance with ASTM D2000.
    - c. Bolts and nuts:
      - 1) Electroplated steel in accordance with ASTM A449.
      - 2) Stainless steel in accordance with ASTM F593.

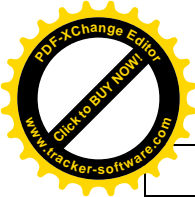


3. Rigid type:
    - a. Victaulic Style 89 and W89 (ductile iron housings).
    - b. Victaulic Style 489 (stainless steel housings).
  4. Flexible type: Victaulic Style 77S.
- C. Bolted, split-sleeve couplings:
1. Split-sleeve type pipe coupling with a fully stainless steel double arch cross section. Coupling shall be designed to close around the pipe ends, confining the gaskets beneath the arches of the sleeve. A watertight, axial seal is created by tightening the bolts to pull the coupling against the outside wall of the pipe.
  2. Manufacturers: One of the following or equal:
    - a. "Expansion x expansion" configuration:
      - 1) Victaulic, Depend-O-Lok, E x E, Type 2 Coupling.
    - b. "Fixed x expansion" configuration:
      - 1) Victaulic, Depend-O-Lok, F x E, Type 2 Coupling.
    - c. "Fixed x fixed" configuration:
      - 1) Victaulic, Depend-O-Lok, F x F, Type 2 Coupling.
    - d. "Fixed x fixed modified" configuration:
      - 1) Victaulic, Depend-O-Lok, F x F, Type 2 Modified Restrained Coupling.
  3. Materials:
    - a. Couplings: Stainless steel in accordance with ASTM A240.
    - b. Bolts and nuts: In accordance with ASTM F593 and ASTM F594.
  4. Pipe preparation:
    - a. Pipe ends shall be smooth for expansion or contraction requirements.
    - b. Where thrust restraint is required or is indicated on the Drawings, pipe ends shall include restraint rings affixed for pipe end restraint requirements.
    - c. The coupling manufacturer shall provide restraint rings that shall be shop welded to the pipe in accordance with the manufacturer's requirements.
    - d. Follow coupling manufacturer's recommendation for size and amount of welding required to attach the restraint rings to the pipe.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with manufacturer's instructions.
- B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.
- C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
  1. Install flexible coupling with pipe gap located in middle of center sleeve.
  2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.



Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

- D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
- E. Grooved joint couplings:
1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
  2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.
- F. Bolted, split-sleeve couplings:
1. Inspect each coupling to insure that there are no damaged portions of the coupling.
    - a. Pay particular attention to the sealing pad/sealing plate area.
    - b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all time.
  2. Wrenches:
    - a. Conform to manufacturer instructions.
    - b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
    - c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
  3. No joint shall be misfit in any plane.
  4. On the fixed ends of bolted, split-sleeve couplings, the shoulders shall bear on the restraint rings all around with no visible gap.
  5. Ends of piping where coupler are installed shall be smooth and free of defects.
    - a. Remove weld splatter and grind smooth.
    - b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION



## SECTION 15211

### DUCTILE IRON PIPE: AWWA C151 - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Ductile iron pipe, joints, connections, and fittings.
- A. As specified in Section 15052 - Common Work Results for General Piping - Plant.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. American Water Works Association (AWWA):
  - 1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
  - 2. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - 3. C115 - Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
  - 4. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
  - 5. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
  - 6. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
  - 7. C606 - Standard for Grooved and Shouldered Joints.
- C. American Welding Society (AWS):
  - 1. D11.2 - Guide for Welding Iron Castings.
- D. ASTM International (ASTM):
  - 1. A47 - Standard Specifications for Ferritic Malleable Iron Castings.
  - 2. A536 - Standard Specifications for Ductile Iron Castings.
- E. Ductile Iron Pipe Research Association (DIPRA):
  - 1. Thrust Restraint Design Manual.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.
- C. Shop drawings:
  - 1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
  - 2. Thrust restraint systems.





3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.
4. Pipe coatings and linings as specified in Section 09997 - Pipeline Coatings and Linings.

D. Calculations:

1. Calculations for thrust restraint system design.

E. Welded outlets:

1. Upon request, Contractor shall provide test results from the manufacturer indicating typical mechanical properties of the utilized weld material (an all-weld sample), as well as typical mechanical properties from transverse tensile and impact specimens machined from butt-weld joined ductile iron pipe coupons to show the suitability or equivalence of the electrodes used.
2. Manufacturer's air-test logs documenting air-leakage tests on all welded-on outlet pipes. Documentation of 500 pounds per square inch hydrostatic testing results may be provided as an alternative to air testing.
3. Proof test data confirming the design, hydrostatic test results, and safety factors for welded outlets.

F. Manufacturer's source testing.

#### **1.04 QUALITY ASSURANCE**

- A. Ductile iron pipe shall be supplied by a single manufacturer.
- B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURED UNITS**

- A. Ductile iron piping:
  1. Manufacturers
    - a. American Cast Iron Pipe Co.
    - b. Pacific States Cast Iron Pipe Co.
    - c. SIP Industries.
    - d. U.S. Pipe.

#### **2.02 DUCTILE IRON JOINTS AND CONNECTIONS**

- A. General:
  1. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052 - Common Work Results for General Piping.
  2. In accordance with AWWA C150 and AWWA C151.
  3. Joints:
    - a. Flanged.
    - b. Grooved.
    - c. Mechanical.
    - d. Push-on Rubber Gasket.
    - e. Integrally Restrained Mechanical.
    - f. Mechanical Wedge Action.





- g. Integrally Restrained Push-On.
- h. Push-On Joint Restraint Harness.
- 4. Connections:
  - a. Tapping saddle.
  - b. Tapping sleeve.
  - c. Welded outlet.
- 5. Fittings.

B. Joints:

- 1. Flanged joints:
  - a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
    - 1) Ductile iron.
    - 2) Long hub, threaded, and specially designed for ductile iron pipe.
    - 3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
  - b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
  - c. Cap screw or stud bolt holes: Tapped.
  - d. Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
  - e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052 - Common Work Results for General Piping.
- 2. Grooved joints: In accordance with AWWA C606, as complemented and modified below, radius-cut type, with following components:
  - a. Couplings: Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510.
  - b. Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
  - c. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
  - d. Fittings: In accordance with AWWA C606, rigid radius-cut groove:
    - 1) Center-to-center dimensions: In accordance with AWWA C110.
    - 2) Wall thickness and other characteristics: In accordance with AWWA C606.
  - e. Flanged unit connections: Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
- 3. Mechanical joints: In accordance with AWWA C111.
  - a. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
  - b. Bolts and nuts, including T-bolts: As specified in Section 15052 - Common Work Results for General Piping.
- 4. Push-on rubber gasket joints: In accordance with AWWA C111.
  - a. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
- 5. Mechanical wedge action joint restraints:
  - a. Manufacturers: One of the following or equal:
    - 1) EBAA Iron, Inc., Megalug® Series 1100.
    - 2) Star Pipe Products, Split Stargrip Series 3000.
    - 3) Sigma Corp., One-Lok Model SLDE.



- b. Materials:
    - 1) Gland body: Ductile iron in accordance with ASTM A536.
    - 2) Wedges and wedge actuating components: Ductile iron in accordance with ASTM A536.
      - a) Wedges shall be heat treated to a minimum of 370 BHN.
    - 3) Actuating bolts and nuts: Ductile iron in accordance with ASTM A536.
      - a) Provide torque-limiting twist off components to ensure proper installation.
    - 4) Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
  - c. Coatings:
    - 1) Provide manufacturer applied coating system.
    - 2) Manufacturers: One of the following or equal:
      - a) EBAA Iron Inc., Mega-Bond.
      - b) Star Pipe Products, Star-Bond.
      - c) Sigma Corp., Corrsafe™ Electro-deposition coating.
  - d. Working pressure:
    - 1) Shall include a minimum safety factor of 2:1.
    - 2) For sizes 3- through 16-inch: 350 pounds per square inch.
    - 3) For sizes 18- through 48-inch: 250 pounds per square inch.
  - e. Restraint shall consist of multiple gripping wedges incorporated into a follower gland meeting the requirements of AWWA C111.
  - f. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
  - g. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.
6. Push-on joint restraint harnesses:
- a. Manufacturers: One of the following or equal:
    - 1) EBAA Iron, Inc., Megalug® Series 1700.
    - 2) Star Pipe Products, Split Stargrip Series 3100S.
    - 3) Sigma Corp., One-Lok Model SLDEH.
  - b. Materials:
    - 1) Restraint and backup ring: Ductile iron in accordance with ASTM A536.
    - 2) Wedges and wedge actuating components: Ductile iron in accordance with ASTM A536.
      - a) Wedges shall be heat treated to a minimum of 370 BHN.
    - 3) Actuating bolts and nuts: Ductile iron in accordance with ASTM A536.
      - a) Provide torque-limiting twist off components to ensure proper installation.
    - 4) Tie rods: Low alloy steel in accordance with AWWA C111.
    - 5) Bolts and nuts, including T-bolts: As specified in 15052 - Common Work Results for General Piping.
  - c. Coatings:
    - 1) Provide manufacturer applied coating system.
    - 2) Manufacturers: One of the following or equal:
      - a) EBAA Iron Inc., Mega-Bond.
      - b) Star Pipe Products, Star-Bond.
      - c) Sigma Corp., Corrsafe™ Electro-deposition coating.



- d. Working pressure:
  - 1) Shall include a minimum safety factor of 2:1.
  - 2) For sizes 3- through 16-inch: 350 pounds per square inch.
  - 3) For sizes 18- through 48-inch: 250 pounds per square inch.
- e. Restraint shall consist of a backup ring behind the ductile iron bell and a restraint ring consisting of multiple gripping wedges connected with number and type of tie rods as recommended by the manufacturer.
- f. Restraint shall allow post assembly deflection of a minimum of 50 percent of the deflection capability of the push-on joint.

C. Connections:

- 1. Tapping saddle as specified in Owner standard specification.
- 2. Tapping sleeve as specified in Owner standard specification.
- 3. Welded outlet.
  - a. Provide weld-on outlets as indicated on the Drawings.
  - b. Fabrication:
    - 1) Welded outlets shall be fabricated by the pipe manufacturer at the same facility where the pipe is produced.
    - 2) Application is limited to branch outlets having a nominal diameter not greater than 70 percent of the nominal diameter of the main line pipe or 36 inches.
    - 3) Parent pipe and branch outlet candidate pipe shall be centrifugally cast ductile iron pipe designed in accordance with AWWA C150 and manufactured in accordance with AWWA C151. Minimum classes for parent and outlet pipe:
      - a) Sizes 4- through 54-inch: Special Thickness Class 53.
      - b) Sizes 60- through 64-inch: Pressure Class 350.
    - 4) Electrodes for reinforcing welds:
      - a) Manufacturers: One of the following or equal:
        - (1) NCO Alloys, Ni-Rod 55-0 flux cored wire.
        - (2) INCO Alloys, Ni-Rod 55 welding electrode.
        - (3) Stooddy Castweld, Ni 55-0 flux cored wire.
        - (4) INCO Alloys, Ni-Rod 44 Filler Metal.
      - b) Carbon steel electrodes are not acceptable.
- c. Pressure rating:
  - 1) Welded outlets 6- through 30-inch: Rated for a working pressure of 250 pounds per square inch.
  - 2) Welded outlets 36-inch and larger: Rated for 200 pounds per square inch.
  - 3) Welded outlets of all diameters and configurations:
    - a) Have a minimum safety factor of 2.0 based on proof of design hydrostatic test results.
    - b) The Contractor shall, at the request of Engineer, provide the manufacturer's representative proof test data confirming the design, hydrostatic test results, and safety factors.
- d. Source quality control:
  - 1) Branch outlets shall be subjected to an air pressure test of at least 15 pounds per square inch.
    - a) Air leakage is not acceptable.



- b) Any leakage shall be detected by applying an appropriate foaming solution to the entire exterior surface of the weldment and adjoining pipe edges or by immersing the entire area in a vessel of water and visually inspecting the weld surface for the presence of air bubbles.
    - c) Hydrostatic testing to 500 pounds per square inch on each branch outlet can be used in lieu of air testing.
    - d) Any weldment that shows any signs of leakage shall be repaired and retested in accordance with the manufacturer's written procedures.
  - 2) Pipe manufacturer shall have a fully documented welding quality assurance system and maintain resident quality assurance records in accordance with AWS D11.2.
  - 3) Pipe manufacturer shall maintain appropriate welding procedure specification, procedure qualification, and welder performance qualification test records as well as appropriate air-test logs documenting air-leakage tests on all welded-on outlet pipes furnished to the Project.
- D. Fittings:
  - 1. Ductile iron in accordance with AWWA C110.
  - 2. Joint type: Same as that of the associated piping as specified in Section 15052 - Common Work Results for General Piping.
  - 3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. General:
  - 1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 15052 - Common Work Results for General Piping.
  - 2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318 - Trenching.
- B. Joints:
  - 1. Install types of joints as specified in the piping schedule provided in Section 15052 - Common Work Results for General Piping.
  - 2. Mechanical joints are not acceptable in above ground applications.
  - 3. Field closure for restrained push-on pipe:
    - a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
  - 4. Grooved joints:
    - a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 - Common Work Results for General Piping.
    - b. Assemble grooved joints in accordance with manufacturer's published instructions.
    - c. Support grooved-end pipe in accordance with manufacturer's published instructions.
      - 1) Install at least 1 support between consecutive couplings.



- C. Connection:
1. Tapping ductile iron pipe:
    - a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
      - 1) Maximum allowable tap diameter by pipe diameter and pressure class:
    - b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
    - c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.
  2. Direct tapping of glass lined ductile iron pipe may be performed only when approved in writing by the Engineer. Direct tapping of glass lined pipe shall be performed in accordance with the above conditions for tapping ductile iron pipe in addition to the following conditions:
    - a. Drilling and tapping shall be performed using a hole saw.
      - 1) Use of a large drill bit is not acceptable.
    - b. As the hole saw approaches the glass lining, lessen the inward pressure to avoid excess chipping or cracking of the lining.
    - c. Minor chipping or spalling of the glass lining shall be repaired using an epoxy resin "glass repair kit" provided by the fabricator.
      - 1) Manufacturers: One of the following or equal:
        - a) Devoe - Devran 224 HS.
        - b) Sherwin-Williams Co. - Sher-Tile High Solids Epoxy.
      - 2) Repair kit use is only allowed for areas of damage less than 1/2 inch in diameter.
        - a) Larger areas of damage will require replacement.
      - 3) Surface shall be prepared and repair kit shall be applied in accordance with manufacturer and/or fabricator's instructions.

### **3.02 FIELD QUALITY CONTROL**

- A. Testing ductile iron piping:
1. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 15249

### POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Schedule type PVC pipe and fittings.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  - 1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  - 2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
  - 3. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
  - 4. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
  - 5. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
  - 6. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
  - 7. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
- B. NSF International (NSF):
  - 1. 61 - Drinking Water System Components - Health Effects.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

##### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.
- C. Store and handle as recommended by manufacturer in published instructions.



## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
  - 1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
    - a. Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
    - b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
  - 2. Fittings: In accordance with ASTM D2467.
    - a. Same material as the pipe and of equal or greater pressure rating.
    - b. Supplied by pipe manufacturer.
    - c. Unions 2-1/2 inches and smaller:
      - 1) Use socket end screwed unions.
    - d. Unions 3 inches and larger:
      - 1) Use socket flanges with 1/8-inch full-face soft EPDM gasket.
  - 3. Solvent cement:
    - a. In accordance with ASTM D2564.
    - b. Manufacturers: The following or equal:
      - 1) IPS Corp.
    - c. Certified by the manufacturer for the service of the pipe.
    - d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.
    - e. Primer: As recommended by the solvent cement manufacturer.

### **2.02 SOURCE QUALITY CONTROL**

- A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.
- B. Provide molded transition fittings for transitions from plastic to metal pipe.
  - 1. Do not thread pipe.
- C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
- D. Provide serrated nipples for transition from pipe to rubber hose.
- E. Solvent weld joints in accordance with ASTM D2855.





### **3.02 FIELD QUALITY CONTROL**

- A. Test pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 15259

### CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE: ASTM F441

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: ASTM F441 CPVC pipe and fittings.

##### 1.02 REFERENCES

- A. ASTM International (ASTM):
  1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
  2. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
  3. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
  4. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
  5. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
  6. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

##### 1.03 ABBREVIATIONS

- A. CPVC: Chlorinated polyvinyl chloride.

##### 1.04 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

#### PART 2 PRODUCTS

##### 2.01 MATERIALS

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
- B. Pipe:
  1. In accordance with ASTM F441 and Appendix, CPVC 4120.
  2. Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D1784.
  3. Schedule 80, unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.



4. Manufacturers: One of the following or equal:
  - a. Charlotte Pipe and Foundry Co.
  - b. Eslon Thermoplastics, Inc.
  - c. GF Harvel.
  - d. Spears Manufacturing Co.
  - e. Chemtrol.
- C. Fittings:
  1. In accordance with ASTM F438 or ASTM F439 for pressure fittings, as appropriate to the service and pressure requirement.
  2. Same material as the pipe and of equal or greater pressure rating.
  3. Supplied by pipe manufacturer.
- D. Solvent cement:
  1. In accordance with ASTM F493.
  2. Manufacturers: The following or equal:
    - a. IPS Corp.
  3. Certified by the manufacturer for the service of the pipe.
  4. Primer: As recommended by the solvent cement manufacturer.
- E. Unions 2-1/2 inches and smaller:
  1. Socket end screwed unions.
- F. Unions 3 inches and larger:
  1. Socket flanges with 1/8-inch full-face soft Viton gasket.

## **2.02 SOURCE QUALITY CONTROL**

- A. Mark pipe and fittings in accordance with ASTM F441.

## **PART 3 EXECUTION**

### **3.01 DELIVERY, STORAGE, AND HANDLING**

- A. Protect from sunlight, scoring, and distortion.
- B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.
- C. Store and handle as recommended by manufacturer in published instructions.

### **3.02 INSTALLATION**

- A. General:
  1. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
  2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe.
    - a. Do not thread pipe.
  3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
  4. Provide serrated nipples for transition from plastic pipe to rubber hose.



- B. Installation of piping:
1. Clean dirt and moisture from pipe and fittings.
  2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file.
    - a. Remove burrs.
  3. Use solvent cement and primer formulated for CPVC.
  4. Use primer on pressure and non-pressure joints.
  5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

### **3.03 FIELD QUALITY CONTROL**

- A. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION





## SECTION 15270

### STEEL PIPE: ASTM A53 - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Steel pipe: Galvanized and black, ASTM A53.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
  - 1. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
  - 2. B16.5 - Pipe Flanges and Flanged Fittings.
  - 3. B16.9 - Factory-Made Wrought Buttwelding Fittings.
- B. American Water Works Association (AWWA):
  - 1. C110 - Ductile-Iron and Gray-Iron Fittings.
  - 2. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines- Enamel and Tape-Hot Applied.
  - 3. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 Inches and Larger-Shop Applied.
  - 4. C206 - Field Welding of Steel Water Pipe.
  - 5. C602 - Standard for Cement-Mortar Lining of Water Pipelines in Place- 4 inches and Larger.
  - 6. C606 - Standard for Grooved and Shouldered Joints.
- C. ASTM International (ASTM):
  - 1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
  - 2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
  - 3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
  - 4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 5. A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
  - 6. A536 - Standard Specification for Ductile Iron Castings.
  - 7. C150 - Standard Specification for Portland Cement.
  - 8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.



## ART 2 PRODUCTS

### 2.01 MATERIALS

- A. Portland cement: In accordance with ASTM C150, Type II, low alkali.

### 2.02 MANUFACTURED UNITS

- A. Steel pipe:
1. General:
    - a. In accordance with ASTM A53.
      - 1) Type: Type E - electric-resistance welded or Type S - seamless.
      - 2) Grade: Grade A or B.
    - b. Schedule:
      - 1) As indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
      - 2) Minimum Schedule unless otherwise indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule:
        - a) Pipe 6 inches and smaller: Schedule 40.
        - b) Pipe greater than 6 inch to 12 inch: Schedule 20.
        - c) Pipe greater than 12 inch: 0.25 inches.
- B. Pipe fittings:
1. Flanged and welding fittings:
    - a. Butt-weld fittings in accordance with ASME B16.9.
    - b. Schedule of fittings: Same class or thickness as the pipe to which it connects.
  2. Screwed fittings:
    - a. Malleable iron:
      - 1) Class 150 or Class 300 in accordance with ASME B16.3, as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
      - 2) Galvanized in accordance with ASTM A153 where used with galvanized pipe.
  3. Grooved joint fittings:
    - a. Fittings for grooved joint steel piping: Rigid-grooved type.
    - b. Fittings for grooved joint piping:
      - 1) Manufacturers: One of the following or equal:
        - a) Victaulic Co. of America.
        - b) Grinnell.
        - c) Anvil.
      - 2) Ductile iron fittings:
        - a) Larger than 4 inches in diameter: In accordance with ASTM A536, Grade 65-45-12, long radius, per AWWA C110.
        - b) Less than 4 inches in diameter: Malleable iron conforming to ASTM A47, Grade 32510.
      - 3) Where cast fittings are not made, forged steel in accordance with ASME B 16.9, ASTM A105, Grade B with 0.375 inch minimum wall thickness.
        - a) Bends: Long radius.





- 4) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint coupling.
- 5) Fittings for grooved joint piping shall be for rigid-grooved type joints. Connection to flanged units shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items, minimum length, 4 inches.

C. Pipe joints:

1. General:

- a. Use type of pipe joints as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
- b. In addition to the type of pipe joints indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule, use flexible couplings, unions or flanged joints to allow ready assembly and disassembly of the piping.

2. Flanged joints:

- a. In accordance with ASME B16.5, steel, 150 pounds, slip-on or weld neck, galvanized in accordance with ASTM A153 where used with galvanized pipe.
- b. Companion flanges:
  - 1) In accordance with ASME B16.5, steel.
  - 2) Class 150 pounds, slip-on or welding neck.
- c. Weld flanges to pipe or fittings before applying lining.
- d. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
- e. Match pipe flanges to the valve flanges.
- f. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
- g. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

3. Grooved joints:

- a. Grooves: Cut grooves. Rolled grooves are not acceptable.
- b. Couplings housing: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
- c. Bolts and nuts: In accordance with ASTM A183, Grade 2.
- d. Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
  - 1) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
  - 2) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of neoprene in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
- e. Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
  - 1) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
  - 2) Shoulder: Type B or D in accordance with AWWA C606.



- f. Couplings and grooving:
        - 1) Manufacturers: One of the following or equal:
          - a) Victaulic Co.
          - b) Grinnell.
          - c) Anvil.
      - g. Grooved joint piping shall not be used in the following installations:
        - 1) In underground and underwater installations.
        - 2) In piping subject to test pressures of 150 pounds per square inch gauge, or more.
        - 3) In steam and gas piping.
        - 4) In sludge and scum piping designed to be steam cleaned.
    - 4. Welded joints: Butt welds, 2 pass, full depth with beveled ends and no backing rings.
  - D. Pipe lining and coating:
    - 1. General:
      - a. Lining and coating shall be as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping.
    - 2. Pipe coating:
      - a. Extend pipe coating for underground piping 6 inches above finish grade or finish floor, and neatly terminate.
      - b. Field paint aboveground steel pipe as specified in Execution of this Section.
      - c. Coat exposed piping as specified in Section 09960 - High-Performance Coatings.
      - d. Coat submerged piping as specified in Section 15052 - Common Work Results for General Piping pipe schedule and Section 09960 - High-Performance Coatings.
      - e. Cement-mortar coating:
        - 1) Cement-mortar coating: In accordance with AWWA C205, modified as follows:
          - a) Sand: In accordance with AWWA C205 except that the total percentage of deleterious material shall not exceed 3 percent.
      - f. Plastic tape wrap: As specified in Section 15274 - Plastic Tape Wrap for Pipe.
        - 1) For buried pipe, wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat, total thickness of tape 80 mils.
    - 3. Pipe lining:
      - a. Cement-mortar lining:
        - 1) Shop apply cement-mortar lining in accordance with AWWA C205. At the option of Contractor, field apply with a pipe lining machine.
      - b. Coal-tar enamel lining:
        - 1) Coal-tar enamel lining for interior of steel pipe: In accordance with AWWA C203.
      - c. Coal-tar epoxy lining:
        - 1) Coal-tar epoxy lining: Epoxy bituminous coating as specified for submerged metal in Section 09960 - High-Performance Coatings.
      - d. Fusion epoxy:
        - 1) Fusion bonded epoxy as specified for submerged metal or exposed metal in Section 15057 - Fusion Bonded Epoxy Lining.



- e. High solids epoxy:
  - 1) High solids epoxy as specified for submerged metal or exposed metal in Section 09960 - High-Performance Coatings.
- f. Polyurethane lining:
  - 1) Polyurethane as specified for submerged metal in Section 09960 - High-Performance Coatings.

## **2.03 FABRICATION**

- A. Shop coat of primer:
  - 1. Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
  - 2. Primer compatible with finish coating system.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Pipe joints:
  - 1. General:
    - a. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is as specified in Section 15052 - Common Work Results for General Piping pipe schedule or as indicated on the Drawings.
    - b. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
    - c. Unless otherwise indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule, pipe joints shall be as follows:
      - 1) Pipe smaller than 2 inches in nominal diameter shall have screwed joints, welded joints, unions, or flexible couplings.
      - 2) Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
      - 3) Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.
  - 2. Flanged joints:
    - a. Flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
    - b. Secure welding neck flanges with full penetration butt welds without backing rings.
    - c. Secure slip-on flanges with both internal and external welds.
    - d. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.
  - 3. Grooved joints:
    - a. Assemble in accordance with manufacturer's published instructions.
    - b. Support grooved joint pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.



4. Screwed joints:
    - a. Perform threading with clean, sharp dies.
      - 1) Wavy, rough, or otherwise defective pipe threads are not acceptable.
    - b. Make screwed joints tight and clean with an application of Teflon™ tape or paste compound applied to the male threads only, except as follows:
      - 1) Make up liquid and liquefied petroleum gas lines, with litharge and glycerin.
    - c. Provide railroad type unions with bronze-to-iron seat. Galvanized where used with galvanized pipe.
      - 1) Flanged joints may be used instead of unions.
  5. Welded joints:
    - a. Field welded joints: Electric arc welded in accordance with AWWA C206.
    - b. Welder's qualification: Qualified in accordance with AWWA C206.
      - 1) Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
    - c. Do not weld galvanized pipe.
- B. Pipe lining and coating:
1. Pipe lining:
    - a. Field applied cement-mortar lining shall be of the same density, smoothness, and thickness as shop applied lining, and in accordance with AWWA C602.
  2. Pipe Coating:
    - a. Plastic tape wrap application:
      - 1) Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat.
      - 2) Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape as specified in this subparagraph.
    - b. Field coat aboveground steel pipe as specified in Section 09960 - High-Performance Coatings.

### **3.02 FIELD QUALITY CONTROL**

- A. Field test fabricated steel manifolds with the pipe to which they connect.

END OF SECTION



## SECTION 15274

### PLASTIC TAPE WRAP FOR PIPE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Plastic tape wrap for pipe.

##### 1.02 REFERENCES

- A. American Water Works Association (AWWA):
  - 1. C209 - Standard for Cold-Applied Tape Coating for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
  - 2. C214 - Standard for Tape-Coating Systems for the Exterior of Steel Water Pipelines.
- B. National Association of Corrosion Engineers (NACE):
  - 1. RP0274-74 - Standard Recommended Practice.

##### 1.03 SUBMITTALS

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data.

#### PART 2 PRODUCTS

##### 2.01 MANUFACTURED UNITS

- A. Plastic tape wrap for exterior of steel pipe, fittings and specials:
  - 1. In accordance with AWWA C209 and AWWA C214.
  - 2. Tape coating system:
    - a. Consist of the following:
      - 1) Primer.
      - 2) First layer of spirally applied 20 mil inner wrap.
      - 3) Middle layer of spirally applied 30 mil outer wrap.
      - 4) Finish layer of spirally applied 30 mil outer wrap.
      - 5) Minimum total coating thickness of 80 mils.
    - b. All materials shall be of products of the same manufacturer.
  - 3. Primer:
    - a. Manufacturers: The following or equal:
      - 1) Polyken Pipeline Coatings, Number 1019 or 1027 Primer.
      - 2) The Tapecoat Co., TC Omniprime Primer.
  - 4. Pipe wrap:
    - a. First wrap:
      - 1) Manufacturers: The following or equal:
        - a) Polyken Pipeline Coatings, Number 980-20 (932-50 for fittings).



- b. Middle wrap:
  - 1) Manufacturers: The following or equal:
    - a) Polyken Pipeline Coatings, Number 955-30.
- c. Finish wrap:
  - 1) Manufacturers: The following or equal:
    - a) Polyken Pipeline Coatings, Number 955-30 White.
- 5. Filler tape:
  - a. Manufacturers: The following or equal:
    - 1) Polyken, Number 939.
- 6. Joint wrap:
  - a. Manufacturers: The following or equal:
    - 1) Polyken, Number 932-50, white Hi-Tack Joint Wrap tape.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Plastic tape wrap application procedures shall be in accordance with manufacturer's published instructions.
  - 1. Apply plastic tape wrap in accordance with AWWA C209.
  - 2. Apply primer with brush, without runs and drips.
  - 3. Lap wrapping not less than 1/2-inch. A single wrap lapped 50 percent or more will not be acceptable.
  - 4. Application on welded joints:
    - a. Remove sharp edges of weld spatter and slag with a file or ball peen hammer before wrapping welded joints.
    - b. Clean and prime all surfaces:
      - 1) Then apply a wrap of 0.125-inch thick by 2 inches wide filler tape centered on the weld.
      - 2) Push and knead the tape into all voids.
      - 3) Start first wrapping 4 inches back on the pipe wrap, spiral wrap tape over the welded joint holding the proper tension and overlap, and finish 4 inches back on the pipe wrap on the other side of the joint.
    - c. Apply 2 wraps of 30 mil joint tape, or the tape may be half lapped to obtain the double thickness.
    - d. Apply finish wrapping in same manner.
  - 5. Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat for a total thickness of 80 mils.
  - 6. Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape.



### 3.02 FIELD QUALITY CONTROL

- A. Holiday detection testing:
  - 1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with plastic tape wrap prior to burying.
    - a. Perform high voltage electrical inspection in accordance with NACE RP0274-74.
    - b. Test voltage used for the electrical inspection of the piping and fittings shall be in accordance with the recommendations given by the tape coating manufacturer in their published literature.
    - c. Repair all holidays and defects found in the coating system by high voltage electrical inspection in accordance with the tape coating manufacturer's recommendations.
    - d. Retest repaired areas in the coating prior to burial of the piping.
  - 2. Before conducting holiday detection testing on any piping systems, submit technical literature and data describing the testing instrumentation, equipment, electrodes, and other accessories that will be used.
    - a. The literature and data shall include complete information covering the operation and use of the testing equipment, including operational voltage ranges.
  - 3. All holiday detection testing and coating repair work shall be witnessed and inspected by the Engineer.

END OF SECTION







## SECTION 15286

### STAINLESS STEEL PIPE AND TUBING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Stainless steel piping and tubing.

##### 1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
  2. B16.11 - Forged Fittings, Socket-Welded and Threaded.
  3. B31.3 - Process Piping.
  4. B36.19 - Stainless Steel Pipe.
- B. American Welding Society (AWS):
1. D1.6 - Structural Welding Code - Stainless Steel.
- C. ASTM International (ASTM):
1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
  2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
  3. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
  4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
  5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
  6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
  7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
  8. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
  9. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
  10. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
  11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
  12. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
  13. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.



14. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
15. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
16. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
17. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
18. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

### **1.03 DESIGN REQUIREMENTS**

- A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
  1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
  2. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.
- B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.
- C. Field assembly:
  1. Field welding is prohibited.

### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Product data: As specified in Section 15052 - Common Work Results for General Piping.
- C. Shop drawings:
  1. Detailed layout drawings:
    - a. Dimensions and alignment of pipes.
    - b. Location of valves, fittings, and appurtenances.
    - c. Location of field joints.
    - d. Location of pipe hangars and supports.
    - e. Connections to equipment and structures.
    - f. Location and details of shop welds.
  2. Thickness and dimensions of fittings and gaskets.
  3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
  4. Material specifications for pipe, gaskets, fittings, and couplings.
  5. Data on joint types and components used in the system including flanged joints, grooved joint couplings and screwed joints.



## PART 2 PRODUCTS

### 2.01 STAINLESS STEEL PIPE

- A. General:
  - 1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.
- B. Wall thickness:
  - 1. As specified in Section 15052 - Common Work Results for General Piping.
  - 2. Piping 3 inches in nominal diameter and greater:
    - a. For general service applications with pressures less than 250 pounds per square inch gauge, pipe diameter 24-inches or less, minimum wall thickness corresponding to Schedule 10S.
    - b. For pressures exceeding 250 pounds per square gauge, minimum wall thickness corresponding to Schedule 40S.
  - 3. Piping less than 3 inches in nominal diameter:
    - a. Piping with threaded or grooved joints:
      - 1) Minimum wall thickness corresponding to Schedule 40S.
- C. Piping material and manufacturing:
  - 1. Comply with the requirements outlined in the following table:
- D. Fittings for piping 3 inches in nominal diameter and greater:
  - 1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
  - 2. Manufacturing standard: In accordance with ASTM A774.
  - 3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
  - 4. End configuration: As needed to comply with specified type of joint.
  - 5. Dimensional standards:
    - a. Fittings with weld ends: In accordance with ASME B16.11.
    - b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.
- E. Fittings for piping less than 3 inches in diameter:
  - 1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
  - 2. Manufacturing standard: In accordance with ASTM A403, Class WP.
  - 3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
  - 4. End configuration: As needed to comply with specified type of joint.
  - 5. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials.
- F. Piping joints:
  - 1. Joint types, piping greater than 2 inches in diameter, general:
    - a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
    - b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:



- 1) Piping stub ends with backing flanges.
      - 2) Welded joints.
      - 3) Flanged joints.
      - 4) Grooved joints.
    - c. Joints at valves and pipe appurtenances:
      - 1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
      - 2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters or flanged joints.
        - a) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system, and conforming to requirements as specified in Section 15121 - Pipe Couplings and External Joint Restraints.
    - d. Joints in digester gas, ozone and oxygen piping systems, membrane and reverse osmosis filtration systems:
      - 1) Aboveground piping: Welded, flanged, or grooved, or stub ends with backing flanges.
      - 2) Underwater piping: Welded or flanged.
      - 3) Buried piping: Welded or mechanically restrained.
  2. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, welded or screwed with Teflon tape thread lubricant.
  3. Welded joints:
    - a. Pipe 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
    - b. Piping 4 inches through 12 inches in diameter: Double butt welded joints.
    - c. Piping less than 4 inches in diameter: Single butt-welded joints.
    - d. Mark each weld with a symbol that identifies the welder.
  4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.
  5. Piping stub ends and backing flanges for pipe 3 inches and larger:
    - a. Piping stub ends: Cast stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions.
      - 1) Manufacturers: The following or equal:
        - a) Alaskan Copper Works, Figure SK-38.
    - b. Backing flanges: Forged or plate stainless steel (type to match pipe material) with drilled bolt patterns in accordance with ASME B16.1, Class 125 or ASME B16.5, Class 150, 300 or 600, as scheduled.
      - 1) Manufacturers: The following or equal:
        - a) Alaskan Copper Works, Figure SK-39 (tube) or SK-39P (pipe).
    - c. Stub ends and backing flanges are not allowed for use with wafer style or lugged style valves.
  6. Flanges for Schedule 40S and Schedule 80S pipe:
    - a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
    - b. Material: In accordance with ASTM A182.
- G. Gaskets:
1. Ozone and oxygen service: TFE sheet.
  2. Aeration air service: As specified in Section 15052 - Common Work Results for General Piping.



3. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.
- H. Bolts for flanges and stub end/backing flanges:
  1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head.
    - a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
    - b. Nuts: In accordance with ASTM A194 heavy hex pattern.
- I. Fabrication of pipe sections:
  1. Welding: Weld in accordance with ASME B31.3.
  2. Weld seams:
    - a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
    - b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
    - c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
    - d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.
- J. Cleaning (pickling) and passivation:
  1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
  2. Clean (pickle) and passivate in accordance with ASTM A380 or A967.
    - a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
      - 1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
    - b. Passivation treatments with citric acid are not allowed.
  3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

## **2.02 STAINLESS STEEL TUBING**

- A. Stainless steel tubing:
  1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A269, wall thickness not less than 0.035 inch.
- B. Fittings: Swage ferrule design:
  1. Components made of:
    - a. Type 316 stainless steel.
  2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
  3. Flare type fittings are not acceptable.
  4. Manufacturers: One of the following or equal:
    - a. Crawford Fitting Co., Swagelok.
    - b. Hoke, Gyrolok.
    - c. Parker, CPI.
- C. Valves for use with stainless steel tubing:
  1. Ball type valves with swage ends to match tubing diameter.



2. Constructed from:
  - a. Type 316 stainless steel with TFE seats.
3. Manufacturers: The following or equal:
  - a. Crawford Fitting Co., Swagelok.

## **2.03 SOURCE QUALITY CONTROL**

- A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.
- B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.
- C. Provide written certification that the fittings as supplied are in accordance with ASTM A774.
  1. Supplementary testing is not required.
- D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.
- E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.
- F. Shipment to site:
  1. Protect all flanges and pipe ends by encapsulating in dense foam.
  2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
  3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
  4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
  5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
  6. Engineer may reject material due to improper shipping methods or damage during shipment.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install piping in such a manner as not to impart strain to connected equipment.
- B. Slope horizontal lines so that they can be drained completely.
- C. Provide valve drains at low points in piping systems.
- D. Install eccentric reducers where necessary to facilitate draining of piping system.
- E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.



### **3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS**

- A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

### **3.03 FIELD QUALITY CONTROL**

- A. Test piping to pressure and by method as specified in Section 15052 - Common Work Results for General Piping.
  - 1. If pressure testing is accomplished with water:
    - a. Use only potable quality water.
    - b. Piping: Thoroughly drained and dried or place immediately into service.
- B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

### **3.04 PROTECTION**

- A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
  - 1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
  - 2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
  - 3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without protection from bad weather is prohibited.
  - 4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION







## **SECTION 15294**

### **RUBBER HOSE**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Hose.

##### **1.02 SUBMITTALS**

- A. Product data: Manufacturer's data indicating service type, sizes, materials, and required accessories.

#### **PART 2 PRODUCTS**

##### **2.01 HOSE**

- A. Hose material: Neoprene or acceptable oil resistant material suitable for a working pressure of minimum 500 pounds per square inch, gauge.
- B. Size as indicated on the Drawings fit ends with appropriate combination clamped nipples and threaded ends as indicated on the Drawings.
- C. Hose larger than 1-1/2 inches in size: Industrial fire hose. Provide one 50-foot long hose for each utility station (hose bib and hose rack) provided.
  - 1. Manufacturers: One of the following or equal:
    - a. Goodyear Rubber Products Corp.
    - b. Uniroyal, Inc.
    - c. Goodall Rubber Co.
- D. Hose 1/2-inch through 1-1/2 inch nominal diameter: General purpose hose. Provide one 75 foot long hose for each utility station (hose bib and hose rack) provided.
  - 1. Manufacturers: One of the following or equal:
    - a. Goodyear Rubber Products Corp.
    - b. Uniroyal.
    - c. Goodall Rubber Co.
- E. Equip and fit hose ends with appropriate combination clamped nipples and threaded ends to make up the assembly indicated on the Drawings.

#### **PART 3 EXECUTION**

##### **3.01 INSTALLATION**

- A. Install hose in accordance with manufacturer's published instructions.

**END OF SECTION**





## SECTION 15521

### HOT WATER SYSTEM COMPONENTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Air separator.
  - 2. Pump discharge valve.
  - 3. Pump suction diffuser.
  - 4. Three-way temperature control valves.
  - 5. Automatic air vents.
- B. Inclusion of a specific manufacturer's name in the Specifications does not mean that the specific manufacturer's standard product will be acceptable. Specified manufacturer's or other manufacturer's standard product shall be modified as required to meet the Specifications.

##### 1.02 REFERENCES

- A. American National Standards Institute (ANSI).
- B. American Society of Mechanical Engineers (ASME):
  - 1. Boilers and Pressure Vessels Code. Section VIII - Rules for Construction of Pressure Vessels Division 1.
- C. Instrument Society of Automation (ISA):
  - 1. 75.02.01 - Control Valve Capacity Test Procedures.
- D. National Fire Protection Association (NFPA):
  - 1. 54 - National Fuel Gas Code.
  - 2. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

##### 1.03 SYSTEM DESCRIPTION

- A. Provide all appurtenances necessary for a complete and functioning hot water control loop system, including but not limited to valves, piping, expansion tank, air vents, and drains.
  - 1. Contractor to coordinate with equipment provided in related Sections to ensure a complete functioning system as indicated on the Drawings.
- B. Design requirements:
  - 1. Water piping, drains, and venting: As specified in Section 01410 - Regulatory Requirements and in accordance with NFPA 54, and NFPA 90A.
  - 2. Control valves:  $C_v$  rated in accordance with ISA 75.02.01.
- C. Performance requirements:
  - 1. Performance requirements are included on the individual equipment schedules.



## **1.04 SUBMITTALS**

- A. Shop drawings:
  - 1. The following shall be submitted as specified in Section 01330 - Submittal Procedures and Section 15050 - Common Work Results for Mechanical Equipment:
    - a. Shop drawings for 3-way control valves:
      - 1) Include connection details with the submittals.
      - 2) System layout drawings.
      - 3) Process schematics.
    - b. For all system components:
      - 1) Make, model, and weight of each equipment assembly.
      - 2) Complete catalog information, descriptive literature, specifications, and materials of construction.
      - 3) Detailed structural and mechanical drawings showing the equipment dimensions, size, and installation.
      - 4) Process data and design calculations including flow rates and pressure loss.
      - 5) Factory protective coatings.
      - 6) Anchor bolt calculations and mounting details for each equipment assembly as specified in Sections 01612 - Seismic Design Criteria and 15050 - Common Work Results for Mechanical Equipment.
      - 7) Details of storage and off loading requirements.
      - 8) Sample warranty.
- B. Quality control submittals:
  - 1. Factory functional test report.
  - 2. Field performance test report.
  - 3. Certificate of Compliance with ASME Code Section VIII, Division 1.
  - 4. Certificates of Installation as specified in Section 01756 - Commissioning.
- C. Certificates as specified in Sections 01756 - Commissioning, 15050 - Common Work Results for Mechanical Equipment, and 15958 - Mechanical Equipment Testing.
- D. Warranties.

## **1.05 QUALITY ASSURANCE**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

## **1.06 DELIVERY, STORAGE AND HANDLING**

- A. As specified in Sections 01600 - Product Requirements and 15050 - Common Work Results for Mechanical Equipment.

## **1.07 PROJECT CONDITIONS**

- A. Environmental requirements: As specified in Section 15050 - Common Work Results for Mechanical Equipment.



## **1.08 SEQUENCING AND SCHEDULING**

- A. Coordinate work with restrictions as specified in Section 01140 - Work Restrictions.

## **1.09 WARRANTY**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment unless noted otherwise.
- B. Warrant equipment free of defects in material and workmanship for 2 years from the date of acceptance or date of first beneficial use of the equipment by the Owner, whichever is later.
  - 1. Warranty shall cover parts and labor.
- C. Manufacturer's warranty shall be issued in the Owner's name.

## **1.10 MAINTENANCE**

- A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.
- B. Special tools:
  - 1. Provide the following:
    - a. One calibration meter suitable for use with all balancing valves and pump discharge valves (separate meter for each is required if single unit is not compatible with both).
  - 2. If special tools are required for the service and maintenance of any system components, provide 1 complete set of tools of each type and size required.
- C. Spare parts: Deliver the following as specified in Section 01600 - Product Requirements:
  - 1. One filter element for each filter regulator associated with a 3-way control valve actuator.
- D. Contractor, inspector, and Owner's maintenance representative shall inventory and account for all tools and spare parts delivered to the site.
  - 1. Each party shall sign a turn over agreement.
  - 2. Owner will then take possession and responsibility for items.

## **PART 2 PRODUCTS**

### **2.01 PUMP DISCHARGE VALVE**

- A. Manufacturers: One of the following or equal:
  - 1. Armstrong Flo-Trex.
  - 2. Bell & Gossett Division of ITT Corp., Triple Duty.
  - 3. Mueller Steam Specialty Control Chek.
  - 4. Taco Plus Two Multi-Purpose.
- B. Materials:
  - 1. Body: Cast iron or ductile iron.
  - 2. Disc: Bronze.
  - 3. Seat: Bronze.



4. Stem: Stainless steel.
  5. Spring: Stainless steel.
- C. Features:
1. Shall be a combination non-slam check valve, throttling valve, and isolation valve.
  2. External, calibrated adjustment indicator, and an adjustable memory stop.
  3. Straight pattern or angle pattern as specified or shown.
  4. ANSI standard flange connections unless otherwise specified.
  5. Rated for maximum working pressure of 175 pounds per square inch gauge.
  6. Rated for maximum operating temperature of 250 degrees Fahrenheit.
  7. Valves used in grooved-end piping systems shall have grooved-end type connections if indicated on the Drawings.
  8. Grooved-end connections shall be suitable for use with grooved-end couplings.

## **2.02 PUMP SUCTION DIFFUSER**

- A. Manufacturers: One of the following or equal:
1. Armstrong.
  2. Bell & Gossett Division of ITT Corp.
  3. Paco.
  4. Taco.
- B. Materials:
1. Body: Cast iron or ductile iron.
  2. Cover: Cast iron or ductile iron.
  3. Straightening vanes: Steel.
  4. Orifice cylinder: Steel.
  5. Start-up strainer: Brass or bronze.
- C. Features:
1. Shall be a combination strainer and pressure gradient equalizer.
  2. Suction diffuser inlet connection shall be an integral ANSI standard flange unless otherwise specified or shown.
  3. The suction diffuser inlet connection for grooved-end piping systems shall be grooved-end type, suitable for use with grooved-end couplings.
  4. Inlet size shall be the full line size of the connected pipe.
  5. Outlet size shall be equal to the connected pump's suction inlet size.
  6. Outlet connection shall be integral ANSI standard flange or female threaded outlet connection to match the pump suction inlet.
  7. Rated for maximum working pressure of 175 pounds per square inch gauge.
  8. The suction diffuser shall consist of an angle type body with inlet vanes and a combination diffuser-strainer orifice with 3/16-inch diameter openings.
  9. The unit shall be equipped with a disposable fine mesh start-up strainer, which shall be removed after system start-up.
  10. A flanged and bolted cover shall be provided to allow removal of the strainer without disturbing the piping system connections.
  11. A strainer blowdown opening and plug shall be provided in the suction diffuser body or cover.
  12. The unit shall be provided with an adjustable support foot.



## 2.03 THREE-WAY TEMPERATURE CONTROL VALVES

### A. Valves 6 inches and smaller:

1. Valve:
  - a. Manufacturers: One of the following or equal:
    - 1) Fisher Division of Emerson Process Management, "YS" type design with an electric actuator to suit configuration.
    - 2) Koso Hammel Dahl Division of Koso America, Inc., Series V830, equivalent models.
  - b. Materials:
    - 1) Body, bonnet, and bottom flange: Cast iron.
    - 2) Trim: Type 316 stainless steel.
    - 3) Packing: Teflon V-ring.
  - c. Features:
    - 1) Suitable for operation in response to a proportional 4-20 mA signal transmitted by electronic temperature controllers as indicated on the Drawings and specified in Sections 17100 - Control Strategies and 17101 - Specific Control Strategies.
    - 2) Suitable for service under pressures equal to and less than 125 pounds per square inch gauge, and under a maximum temperature of 220 degrees Fahrenheit.
    - 3) Plug: For open-close or throttling service with a V-port.
2. Electric operator:
  - a. Manufacturers: The following or equal:
    - 1) Rotork IQML.
  - b. Design:
    - 1) As specified in Section 13447 - Electric Motor Actuators.
  - c. Materials:
    - 1) As specified in Section 13447 - Electric Motor Actuators.
  - d. Operator accessories:
    - 1) As specified in Section 13447 - Electric Motor Actuators.
3. Valve sizing:
  - a.  $C_v$  values listed by manufacturer shall be determined in accordance with ISA 75.02.01.
  - b. Control valves shall be selected such that the valve with the  $C_v$  closest to that shown in the valve schedule that provides the best control under the specified pressures and flow rates will be utilized.
  - c. In general, valves for open-close operation shall be line size and valves for modulating operation shall be smaller than line size.
  - d. Contractor to provide reducers where the specific valve is smaller than the connected pipes.
4. 3-Way Temperature Control Valve Schedule:

Control Valve Tag Number	Control Valve Service	Pipe Size, Inches	$C_v$	Flow Direction Used for $C_v$ Determination	Flow, Gallons per Minute	Duty	Failure Position	Flow Type
FCV-214	FOG Hot Water Loop	4	134	All Flow from Side to Side	300	Modulating	Plug Up	Converging, common port on side



.04

## **AUTOMATIC AIR VENTS, HOT WATER SERVICE**

- A. Manufacturers: One of the following or equal:
  - 1. Bell & Gossett Division of ITT Corp., Number 87.
  - 2. Hoffman Specialty Manufacturing Corp., Number 78.
- B. Materials:
  - 1. Body: Brass with non-ferrous internals.
- C. Features:
  - 1. Provided for automatic removal of air entrained within a closed hot water system.
  - 2. Rated for maximum working pressure of 150 pounds per square inch gauge.
  - 3. Rated for maximum operating temperature of 240 degrees Fahrenheit.
  - 4. Vents shall be float-type.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine and verify that Work is in condition to receive installation specified in this Section:
  - 1. Take measurements and verify dimensions to ascertain fit of installation.
  - 2. Ascertain structural sufficiency to support installation.
  - 3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required:
    - a. Submit details of proposed cutting and patching.
  - 4. Confirm specified thermostat or other controls are compatible with specified equipment.
- B. Examine and verify structural details and sections indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.

### **3.02 INSTALLATION**

- A. Install in accordance with manufacturer's installation instructions and as specified in Section 15050 - Common Work Results for Mechanical Equipment.
- B. Provide venting and drains complying with the building code as specified in Section 01410 - Regulatory Requirements, and in accordance with NFPA 54, and NFPA 90A.
- C. Pump suction diffuser:
  - 1. The Contractor shall install suction diffuser on the suction connection of each pump where specified.
    - a. The adjustable support foot shall be mounted on the pump base and adjusted to support the suction diffuser.
    - b. The start-up strainer shall be removed after system start-up is complete.





- D. Circuit balancing valves:
  - 1. Circuit balancing valves shall be installed with at least the minimum length, recommended by the manufacturer, of straight unrestricted pipe upstream and downstream of the specified valve location.

### **3.03 FIELD FINISHING**

- A. Field coat as specified in Section 09960 - High-Performance Coatings.
- B. Air separators, pump discharge valves, suction diffusers, and balancing valves shall be insulated as specified in Section 15082 - Piping Insulation.

### **3.04 FIELD QUALITY CONTROL**

- A. Balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.
- B. Performance and function testing:
  - 1. As specified in Section 01756 - Commissioning.
- C. Certificate of installation:
  - 1. As specified in Section 01756 - Commissioning.

### **3.05 MANUFACTURER'S SERVICES**

- A. Provide training of the Owner's personnel as specified in Section 01756 - Commissioning:
  - 1. Require manufacturer's representative to perform the following services as described below and as specified in Section 01756 - Commissioning. The specified durations are the minimum required time on the job site. Additional services and/or longer durations shall be provided as needed at no cost to the Owner to meet the required quality of work:
    - a. Installation assistance:
      - 1) Check and verify that installation of the electro-pneumatic operators is as indicated on the Drawings and manufacturer's installation instructions.
      - 2) Provide additional assistance as required.
    - b. Installation inspection: 1 trip. One workday each trip for each type of valve and hot water system component.
    - c. Start-up/testing assistance: 1 trip. 2 workdays each trip for each type of valve and hot water system component.
    - d. Training: As specified in Section 01756 - Commissioning. Provide training as follows:
      - 1) Operations training: 2 hours of training, presented twice, for a total of 4 hours.
      - 2) Mechanical maintenance training: 4 hours of training, presented twice, for a total of 8 hours.
      - 3) Electrical maintenance training: 2 hours of training, presented twice, for a total of 4 hours.
    - e. Final acceptance checkout: 1 Workday each trip for each type of valve and hot water system component.
    - f. Post start-up checkout: 1 Workday each trip for each type of valve and hot water system component.



- B. Provide field performance testing and Certificate of Installation.

### **3.06 START-UP PROCEDURES**

- A. Perform start-up and testing as specified in Section 01756 - Commissioning.
- B. During start-up and testing, remove and clean the strainers at the air separator and suction diffusers after 24 hours and again after 30 days of hot water system operation.

END OF SECTION



## SECTION 15956

### PIPING SYSTEMS TESTING - PLANT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Test requirements for piping systems.

##### 1.02 REFERENCES

- A. National Fuel Gas Code (NFGC).
- B. American Society of Mechanical Engineers (ASME):
  - 1. B31.1 - Power Piping.
  - 2. B31.3 - Process Piping.
  - 3. B31.8 - Gas Transmission and Distribution Piping Systems.
- C. Underwriters Laboratories Inc. (UL).

##### 1.03 TESTING REQUIREMENTS

- A. General requirements:
  - 1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
  - 2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
  - 3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01410 - Regulatory Requirements, and UL requirements.
  - 4. Test natural gas or digester gas piping:
    - a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
    - b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
  - 5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
    - a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.
- B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.



- C. Water for testing, cleaning, and disinfecting:
  - 1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500 - Temporary Facilities and Controls.
- D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.
- E. Unsuccessful tests:
  - 1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
  - 2. Repeat testing until tests are successful.
- F. Test completion: Drain and leave piping clean after successful testing.
- G. Test water disposal: Dispose of testing water at the Fourche Creek WRF in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

#### **1.04 SUBMITTALS**

- A. Submit as specified in Section 01330 - Submittal Procedures.
- B. Schedule and notification of tests:
  - 1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
  - 2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
  - 3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

#### **1.05 SEQUENCE**

- A. Clean piping before pressure or leak tests.
- B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.
- C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.
- D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.
- E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.



## **PART 2 PRODUCTS**

Not Used.

## **PART 3 EXECUTION**

### **3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION**

- A. Alignment and grade:
  - 1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
  - 2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.
- B. Deflection test:
  - 1. Pull a mandrel through the clean piping section under test.
  - 2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
  - 3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
  - 4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

### **3.02 AIR TESTING METHOD FOR PRESSURE PIPING**

- A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.
- B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
  - 1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.
- C. Test at pressure as specified in Piping Schedule in Section 15052 - Common Work Results for General Piping:
  - 1. Provide temporary pressure relief valve for piping under test:
    - a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
  - 2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASME B31.8, or the pipe manufacturer's stated maximum working pressure.
  - 3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
  - 4. Perform initial check of joints and fittings for leakage.
  - 5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage; at each step increase until test pressure reached.
  - 6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
  - 7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.



3.03

### TESTING GRAVITY FLOW PIPING

- A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
  - 1. Unless specified otherwise, subject gravity flow piping to the following tests:
    - a. Alignment and grade.
    - b. For plastic piping test for deflection.
    - c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
  - 2. Inspect piping for visible leaks before backfilling.
  - 3. Provide temporary restraints when needed to prevent movement of piping.
  - 4. Pressure test piping with maximum leakage allowance after backfilling.
  - 5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
    - a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
    - b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
    - c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
      - 1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
        - a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
          - (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
        - b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
        - c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

### 3.04 TESTING HIGH-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.
- B. General:
  - 1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
  - 2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
  - 3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.



4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
  5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
  6. When test results indicate failure of selected sections, limit tests to piping:
    - a. Between valves.
    - b. Between a valve and the end of the piping.
    - c. Less than 500 feet long.
  7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Testing procedures:
1. Fill piping section under test slowly with water while venting air:
    - a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
  2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
  3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
    - a. Consider visible leakage testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
  2. Pressure test piping after completion of visible leaks test.
  3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
    - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
    - b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.



- c. When leakage is allowed, calculate the allowable leakage by the following formula:

$$L = S \times D \times P^{1/2} \times 133,200^{-1}$$

wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

### 3.05 TESTING LOW-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.
- B. General:
1. Test pressures shall be as scheduled in Section 15052 - Common Work Results for General Piping.
  2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
  3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
  4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Visible leaks test:
1. Subject piping under test to specified pressure measured at the lowest end.
  2. Fill piping section under test slowly with water while venting air:
    - a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
  3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
  4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
1. Pressure test piping after completion of visible leaks test.





2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
  - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
  - b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:

1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
  - a. Joint testing will be allowed only for low head pressure piping.
  - b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint testing with water:
  - a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
  - b. Maintain test pressure for 1 minute.
  - c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
  - d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
  - e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint testing with air:
  - a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
  - b. Maintain test pressure for 2 minutes.
  - c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION





## SECTION 15958

### MECHANICAL EQUIPMENT TESTING

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes: Testing of mechanical equipment and systems.

##### 1.02 REFERENCES

- A. American National Standards Institute (ANSI):
  - 1. S1.4 Specification for Sound Level Meters.
- B. Hydraulic Institute (HI).
- C. National Institute of Standards and Technology (NIST).

##### 1.03 SUBMITTALS

- A. Project closeout documents:
  - 1. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.
    - a. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

#### PART 2 PRODUCTS

Not Used.

#### PART 3 EXECUTION

##### 3.01 GENERAL

- A. Commissioning of equipment as specified in:
  - 1. This Section.
  - 2. Section 01756 - Commissioning.
  - 3. Equipment sections:
    - a. If testing requirements are not specified, provide Level 1 Tests.
- B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.
- C. Operation of related existing equipment:
  - 1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.
  - 2. Schedule and coordinate testing as required by Section 01756 - Commissioning.



- D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
  - 1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
  - 2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.
- E. Test measurement and result accuracy:
  - 1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
    - a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
  - 2. Do not adjust results of tests for instrumentation accuracy.
    - a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

### **3.02 VARIABLE SPEED EQUIPMENT TESTS**

- A. Establish performance over the entire speed range and at the average operating condition.
- B. Establish performance curves for the following speeds:
  - 1. The speed corresponding to the rated maximum capacity.
  - 2. The speed corresponding to the minimum capacity.
  - 3. The speed corresponding to the average operating conditions.

### **3.03 PUMP TESTS, ALL LEVELS OF TESTING**

- A. Test in accordance with the following:
  - 1. Applicable HI Standards.
  - 2. This Section.
  - 3. Equipment sections.
- B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
  - 1. From 0 to plus 5 percent of head at the specified flows.
  - 2. From 0 to plus 5 percent of flow at the rated design point head.
  - 3. No negative tolerance for the efficiency at the specified flows
  - 4. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

### **3.04 DRIVERS TESTS**

- A. Test motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
- B. Test other drivers as specified in the equipment section.



### **3.05 NOISE REQUIREMENTS AND CONTROL**

- A. Perform noise tests in conjunction with vibration test analysis.
- B. Make measurements in relation to reference pressure of 0.0002 microbar.
- C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
- D. Set sound level meter to slow response.
- E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

### **3.06 PRESSURE TESTING**

- A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

### **3.07 INSPECTION AND BALANCING**

- A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.
- B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
- C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.
- D. Critical speed of rotating equipment:
  - 1. Satisfy the following:
    - a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
    - b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
    - c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.
- E. Vibration tests:
  - 1. Definitions:
    - a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
    - b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.



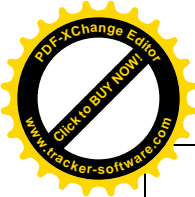
- c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
- d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
- e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
  - 1) Manufacturers: One of the following or equal:
    - a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
    - b) CSI, "PeakVue."
- f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
- g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
- h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
- i. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
- j. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.
- 2. Vibration instrumentation requirements:
  - a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
    - 1) Manufacturers: One of the following or equal:
      - a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
      - b) Pruftechnik, VIBXPERT II.
  - b. Analyzer settings:
    - 1) Units: English, inches/second, mils, and gravitational forces.
    - 2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
    - 3) Sample averages: 4 minimum.
    - 4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
    - 5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
    - 6) Fast fourier transform windowing: Hanning Window.
    - 7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.



- c. Accelerometers:
  - 1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
    - a) Manufacturers: One of the following or equal:
      - (1) Wilcoxon Research, Model 797L.
      - (2) PCB, Model 393C.
  - 2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
    - a) Manufacturers: One of the following or equal:
      - (1) Wilcoxon Research, Model 793.
      - (2) Entek-IRD Model 943.
- 3. Accelerometer mounting:
  - a. Use magnetic mounting or stud mounting.
  - b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
  - c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
- 4. Vibration acceptance criteria:
  - a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
  - b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

- c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:



HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) Vertical Solids Handling Centrifugal Pumps	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

- d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.
- e. Additional criteria:
  - 1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.





- 2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
  - 3) For motors, the following shall be cause for rejection:
    - a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
    - b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
    - c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
    - d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
  - 4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.
5. Vibration testing results presentation:
- a. Provide equipment drawing with location and orientation of measurement points indicated.
  - b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
  - c. When Vibration Spectra Data required:
    - 1) Plot peak vibration velocity versus frequency in cycles per minute.
    - 2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
    - 3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
    - 4) Plot motor spectra on a log amplitude scale versus frequency.
  - d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
  - e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

### **3.08 TESTING LEVELS**

- A. Level 1 Tests:
  1. Level 1 General Equipment Performance Test:



- a. For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
    - b. Operate at rated design load conditions.
    - c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
  2. Level 1 Pump Performance Test:
    - a. Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
    - b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower or the applicable equipment section. Use actual driver for field tests.
    - c. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
  3. Level 1 Vibration Test:
    - a. Test requirement:
      - 1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
      - 2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
    - b. Equipment operating condition: Test at specified maximum speed.
  4. Level 1 Noise Test:
    - a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.
- B. Level 2 Tests:
  1. Level 2 General Performance Test:
    - a. For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
    - b. Operate at rated design load conditions.
    - c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
  2. Level 2 Pump Performance Test:
    - a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.



- b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
  - c. Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
  - d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
3. Level 2 Vibration Test:
- a. Test requirement:
    - 1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
    - 2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
  - b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
  - c. Natural frequency test of field installed equipment:
    - 1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
    - 2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
    - 3) Perform with equipment and attached piping full of intended service or process fluid.
4. Level 2 Noise Test:
- a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:

- 1. Level 3 General Equipment Performance Tests:
  - a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
  - b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
  - c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
  - d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.



- e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
  - 2. Level 3 Pump Performance Test:
    - a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
    - b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
    - c. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
    - d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
  - 3. Level 3 Vibration Test:
    - a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
    - b. Perform High Frequency Enveloping Analysis for gears and bearings.
      - 1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
      - 2) Report results in units of acceleration versus frequency in cycles per minute.
    - c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
    - d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
  - 4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.
- D. Level 4 Tests:
- 1. Level 4 General Equipment Performance Test:
    - a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
    - b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.



- c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
  - d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
  - e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
2. Level 4 Pump Performance Test:
- a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
  - b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
  - c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
  - d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
  - e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
    - 1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
    - 2) Perform efficiency testing with test fluids at maximum rated speed.
    - 3) Perform priming time testing with test fluids at maximum rated speed.
3. Level 4 Vibration Test: Same as Level 3 vibration test.
4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION





## SECTION 16050

### COMMON WORK RESULTS FOR ELECTRICAL

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. General requirements applicable to all Electrical Work.
  - 2. General requirements for electrical submittals.
- B. Interfaces to equipment, instruments, and other components:
  - 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
  - 2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
    - a. Make all changes necessary to meet the manufacturer's wiring requirements.
  - 3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700 - General Conditions.
  - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
    - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
  - 5. Loop drawings:
    - a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
      - 1) Conduit numbers and associated signal(s) contained within each conduit.
      - 2) Wire numbers.
      - 3) Equipment terminal numbers.
      - 4) Junction boxes and signal(s) contained within each junction box.
      - 5) Equipment power sources, and associated circuit numbers.
      - 6) As-built drawings detailing wiring.
- C. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
  - 1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
  - 2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.





3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.
- D. Contract Documents:
1. General:
    - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
  2. Specifications:
    - a. The General and Supplementary Conditions of the Contract Documents govern the Work.
    - b. These requirements are in addition to all General Requirements.
  3. Contract Drawings:
    - a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
    - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
      - 1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
      - 2) The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
    - c. Installation details:
      - 1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      - 2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
    - d. Schematic diagrams:
      - 1) All controls are shown de-energized.
      - 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
      - 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      - 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.





- 5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:

1. Coordinate with Document 00700 - General Conditions for substitute item provisions.

F. Changes and change orders:

1. As specified in Document 00700 - General Conditions.

## 1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01410 - Regulatory Requirements.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this Section.
  - a. American National Standards Institute (ANSI).
  - b. American Society of Civil Engineers (ASCE):
    - 1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
  - c. ASTM International (ASTM).
  - d. Illuminating Engineering Society (IES).
  - e. Institute of Electrical and Electronics Engineers (IEEE).
  - f. Insulated Cable Engineers Association (ICEA).
  - g. International Code Council (ICC):
    - 1) International Code Council Evaluation Service (ICC-ES).
      - a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
  - h. International Society of Automation (ISA).
  - i. National Electrical Manufacturers Association (NEMA):
    - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
  - j. National Fire Protection Association (NFPA):
    - 1) 70 - National Electrical Code (NEC).
  - k. National Institute of Standards and Technology (NIST).
  - l. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:

1. As specified in Document 00700 - General Conditions.

## 1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.



8. NIST.

B. Specific definitions:

1. FAT: Factory acceptance test.
2. LCS: Local Control Station
3. ICSC: Instrumentation and controls subcontractor.
4. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
5. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
6. PCIS: Process control and instrumentation system.
7. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
8. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
9. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
10. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
11. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

#### 1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
  - a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any



change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.

5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
  - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
  - b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
6. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
  - a. As specified in the Contract Documents.
7. Defective work:
  - a. As specified in Document 00700 - General Conditions.

**B. Operating facility:**

1. As specified in Section 01140 - Work Restrictions.
2. The Fourche Water Reclamation Facility is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
  - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
  - b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
  - c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

## **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.
- B. General:
  1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
  2. Furnish the submittals required by each section in the Electrical Specifications.
  3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
    - a. Uniquely number each wire.



- b. Wire numbers must appear on all Equipment Drawings.
      4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
    - C. Seismic requirements:
      1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01612 - Seismic Design Criteria.
      2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
        - a. Statement of seismic qualification, and special seismic certification:
          - 1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410 - Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
          - 2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with  $I_p = 1.5$ ." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
        - b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
        - c. Anchoring design calculations and details:
          - 1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612 - Seismic Design Criteria.
      3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
        - a. Temporary or moveable equipment.
        - b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
        - c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.
    - D. Submittal organization:
      1. First page:
        - a. Specification section reference.
        - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
        - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
        - d. Place for Contractor's review stamp and comments.
      2. Next pages:
        - a. Provide confirmation of specification compliance:



- 1) Specification section: Include with each submittal a copy of the relevant specification section.
  - a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
  - b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
- b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
  - 1) In the order that the comments or questions were presented throughout the submittal.
  - 2) Referenced by index section and page number on which the comment appeared.
  - 3) Acceptable responses to Engineer's comments are either:
    - a) Engineer's comment or change is accepted and appropriate changes are made.
    - b) Explain why comment is not accepted or requested change is not made.
    - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
  - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
  - 5) No further review by the Engineer will be performed until a response for previous comments has been received.
3. Remaining pages:
  - a. Actual submittal data:
    - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
    - 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
  - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submit copies of shop drawings, and product data:
  - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:



- a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:
  - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
  - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
  - c. Acceptance of any exception is at the sole discretion of the Engineer.
    - 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
  - d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
7. Specific submittal requirements:
  - a. Shop drawings:
    - 1) Required for materials and equipment listed in this and other sections.
    - 2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
    - 3) Shop drawings requirements:
      - a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
      - b) Locations of conduit entrances and access plates.
      - c) Component layout and identification.
      - d) Schematic and wiring diagrams with wire numbers and terminal identification.
      - e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
      - f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
      - g) Weight.
      - h) Finish.
      - i) Nameplates:
        - (1) As specified in Section 16075 - Identification for Electrical Systems.
      - j) Temperature limitations, as applicable.
  - b. Product data:
    - 1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
    - 2) Include:
      - a) Catalog cuts.
      - b) Bulletins.
      - c) Brochures.
      - d) Quality photocopies of applicable pages from these documents.





- e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
    - f) Identify model number and options for the actual equipment being furnished.
    - g) Neatly cross out options that do not apply or equipment not intended to be supplied.
  - c. Detailed sequence of operation for all equipment or systems.
- F. Operation and maintenance manuals:
  - 1. As specified in Section 01782 - Operation and Maintenance Data.
  - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.
- G. Material and equipment schedules:
  - 1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
    - a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- H. Schedule of values:
  - 1. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
- I. Roof penetrations:
  - 1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.
- J. Record Documents:
  - 1. Furnish as specified in Section 01770 - Closeout Procedures.
  - 2. Provide Record Documents of all Electrical Drawings.
  - 3. Record Drawing requirements:
    - a. Update Record Drawings weekly.
    - b. Record Drawings must be fully updated as a condition of the monthly progress payments.
    - c. Submit Record Drawings upon completion of the Work for final review.
    - d. Clearly and neatly show all changes including the following:
      - 1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
  - 4. Shop drawings:
    - a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
      - 1) Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch paper.



- a) Size all drawings to be readable and legible on 11-17 inch media.
  - 2) Provide electronic copies of these documents on CD-ROM or DVD disks in PDF format.
- 5. Review and corrections:
  - a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
  - b. Promptly correct and re-submit record documents returned for correction.
- K. Test reports:
  - 1. As specified in Section 01330 - Submittal Procedures.
  - 2. Include the following:
    - a. A description of the test.
    - b. List of equipment used.
    - c. Name of the person conducting the test.
    - d. Date and time the test was conducted.
    - e. All raw data collected.
    - f. Calculated results.
    - g. Each report signed by the person responsible for the test.
  - 3. Additional requirements for field acceptance test reports are specified in Sections 01756 - Commissioning and 16950 - Field Electrical Acceptance Tests.
- L. Calculations:
  - 1. Where required by specific Electrical Specifications:
    - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

## **1.06 QUALITY ASSURANCE**

- A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 01600 - Product Requirements.
- B. Shipping precautions:
  - 1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
  - 2. Place dehumidifiers, when required, inside the polyethylene coverings.
  - 3. Skid-mount the equipment for final transport.
  - 4. Provide lifting rings for moving without removing protective covering.
  - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- C. Delivery and inspection:
  - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.





- D. Special instructions:
1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

## 1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
  2. Seismic load resistance:
    - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612 - Seismic Design Criteria.
  3. Wind load resistance:
    - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01614 - Wind Design Criteria.
  4. Altitude, temperature and humidity:
    - a. As specified in Section 01610 - Project Design Criteria.
    - b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
    - c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
      - 1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
  5. Outdoor installations:
    - a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
    - b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
      - 1) Provide all wiring necessary to power these devices.
- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
  2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
  3. NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and



freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.

4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
5. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052 - Hazardous Classified Area Construction.

C. Plant area Electrical Work requirements:

1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Indoor Conditioned Spaces	NEMA 12	Galvanized rigid steel	C	Stainless steel
Outdoor	NEMA 3R	Galvanized rigid steel	W	Stainless steel
Digester Complex Interior	NEMA Type 7	PVC coated galvanized rigid steel	H	Stainless steel
FOG Station	NEMA 4X	Galvanized rigid steel	X	Stainless steel

2. Modify exposed conduit runs as specified in Section 16130 - Conduits.

## 1.09 SEQUENCING (NOT USED)

## 1.10 SCHEDULING

A. General:

1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
2. Testing requirements are specified in Section 01756 - Commissioning, 16950 - Field Electrical Acceptance Tests and other sections.
3. General scheduling requirements are specified in Section 1321 – Schedules and Reports.
4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
5. Commissioning requirements as specified in Section 01756 - Commissioning.

B. Pre-submittal conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.



2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.
- C. Factory acceptance testing (FAT):
  1. Where FAT is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
    - a. Indicate the desired dates for inspection and testing.
    - b. Schedule the FAT after approval of the FAT procedures submittal:
      - 1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
      - 2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

#### **1.11 WARRANTY**

- A. Warrant the Electrical Work as specified in Document 00700 - General Conditions:
  1. Provide additional warranty as specified in the individual Electrical Specifications.

#### **1.12 SYSTEM START-UP**

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
  1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

#### **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.14 MAINTENANCE**

- A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by other sections of the Specifications.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.
- B. Allowable manufacturers are specified in individual Electrical Specifications.

#### **2.02 EXISTING PRODUCTS (NOT USED)**



03

## **MATERIALS**

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in Document 00700 - General Conditions.
- C. Stainless steel:
  - 1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
  - 2. Provide exposed screws of the same alloys.
  - 3. Provide finished material free of any burrs or sharp edges.
  - 4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
  - 5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
  - 6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

### **2.04 MANUFACTURED UNITS (NOT USED)**

### **2.05 EQUIPMENT (NOT USED)**

### **2.06 COMPONENTS (NOT USED)**

### **2.07 ACCESSORIES (NOT USED)**

### **2.08 MIXES (NOT USED)**

### **2.09 FABRICATION (NOT USED)**

### **2.10 FINISHES (NOT USED)**

### **2.11 SOURCE QUALITY CONTROL**

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.
- B. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.



- C. Comply with pre-bid conference requirements as specified in Document 00200 - Instructions to Bidders.
- D. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
  - 1. Verify all dimensions indicated on the Drawings:
    - a. Actual field conditions govern all final installed locations, distances, and levels.
  - 2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
  - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
  - 4. Provide a complete electrical system:
    - a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. Cutting and patching:
  - 1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
    - a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
      - 1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
        - a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
        - b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
    - b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
  - 2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
    - a. 3M: CP 25WB+: Caulk.
    - b. 3M: Fire Barrier: Putty.
  - 3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.



- D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
  - 1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
    - a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
  - 2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
    - a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
  - 3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
  - 4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
- E. Earthwork and concrete:
  - 1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
    - a. Requirements as specified in the Contract Documents.
- F. Roof penetrations:
  - 1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.
- G. Terminations:
  - 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.
- H. Miscellaneous installation requirements:
  - 1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 00700 - General Conditions.
  - 2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
  - 3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
  - 4. Circuits of different service voltage:
    - a. Voltage and service levels:
      - 1) Medium voltage: greater than 1.0 kV.
      - 2) Low voltage: 120 V to 480 V.
      - 3) Instrumentation: Less than 50 VDC.
    - b. Install different service voltage circuits in separate raceways, and junction boxes.
    - c. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.
- I. Labeling:



- J. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
    - a. All control panels must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. For Owner and Engineer witnessed FAT:
1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01756 - Commissioning.
- C. Owner training:
1. As specified in Section 01756 - Commissioning and in this Section.
  2. Provide source testing and owner training on electrical equipment as defined in the table below:

Table1: Source Testing and Owner Training Requirements:

Section Number	Section Title	Source Testing (Witnessed or Non-witnessed)	Owner Training Requirements	
			Maintenance (hrs per session)	Operation (hrs per session)
16262	Variable Frequency Drives 0.50 - 50 Horsepower	Witnessed	8	8
16422	Motor Starters	Non-Witnessed	8	8
16444	Low Voltage Motor Control Centers	Witnessed	N/A	N/A

### **3.08 FIELD QUALITY CONTROL**

- A. Inspection:
1. Allow for inspection of electrical system installation as specified in Section 01450 - Quality Control.
  2. Provide any assistance necessary to support inspection activities.
  3. Engineer inspections may include, but are not limited to, the following:
    - a. Inspect equipment and materials for physical damage.
    - b. Inspect installation for compliance with the Drawings and Specifications.
    - c. Inspect installation for obstructions and adequate clearances around equipment.
    - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.





- e. Inspect equipment nameplate data to verify compliance with design requirements.
- f. Inspect raceway installation for quality workmanship and adequate support.
- g. Inspect cable terminations.
- 4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.
- B. Field acceptance testing (Functional Testing):
  - 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
  - 2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
  - 3. Record results of the required tests along with the date of test:
    - a. Use conduit identification numbers to indicate portion of circuit tested.
- C. Workmanship:
  - 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
    - a. Neatly coil and label spare wiring lengths.
    - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

### **3.09 ADJUSTING (NOT USED)**

### **3.10 CLEANING**

- A. As specified in Section 01770 - Closeout Procedures.
- B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.
- C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
  - 1. Use of compressors or air blowers for cleaning is not acceptable.
- D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction, and return all used lamps to the Owner.
- E. As specified in other sections of the Contract Documents.

### **3.11 PROTECTION**

- A. Protect all Work from damage or degradation until Substantial Completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16052

### HAZARDOUS CLASSIFIED AREA CONSTRUCTION

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and as indicated on the Drawings and specified in the Specifications.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
  - 1. For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

##### 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
  - 1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
  - 2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
  - 3. All devices used in Class I Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.

##### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.08 PROJECT OR SITE CONDITIONS**

- A. The following areas are classified Class I, Division 1:
  - 1. Digester Complex interior.

## **1.09 SEQUENCING**

- A. Conduit seals shall be filled during start-up and commissioning after verification of field wiring. Conduit seals shall be filled prior to the introduction of process or gas to the equipment/area.

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY (NOT USED)**

## **1.12 SYSTEM START-UP (NOT USED)**

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS (NOT USED)**

### **2.02 EXISTING PRODUCTS (NOT USED)**

### **2.03 MATERIALS (NOT USED)**

### **2.04 MANUFACTURED UNITS (NOT USED)**

### **2.05 EQUIPMENT (NOT USED)**

### **2.06 COMPONENTS**

- A. Conduit and sealing fittings:
  - 1. As specified in Section 16130 - Conduits.
- B. Conduit boxes and bodies:
  - 1. As specified in Section 16134 - Boxes.
- C. Wiring devices:
  - 1. As specified in Section 16140 - Wiring Devices.

### **2.07 ACCESSORIES (NOT USED)**

### **2.08 MIXES (NOT USED)**

### **2.09 FABRICATION (NOT USED)**

### **2.10 FINISHES (NOT USED)**



## **2.11 SOURCE QUALITY CONTROL (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Conduit installation:
  - 1. As specified in Section 16130 - Conduits.
  - 2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.
  - 3. Make all conduit connections so that there are a minimum of 5 threads fully engaged in the connection.
  - 4. Flexible conduit:
    - a. Class I Division 1 hazardous areas:
      - 1) Approved and marked suitable for Class I Division 1.
      - 2) Listed for compatibility with the group type atmosphere where used.
    - b. Class I Division 2 areas:
      - 1) Liquidtight metal conduit with approved fittings.
    - c. Maximum length as specified in Section 16130 - Conduits.
- C. Sealing fittings:
  - 1. Provide an approved seal, no more than 12 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
    - a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies similar to "L", "T", and "X" may be installed between the sealing fitting and the enclosure.
  - 2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
    - a. Seals are required in all conduit connections to the compartment containing splices and must be within 12 inches of the enclosure.
  - 3. Install a conduit seal within 12 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
  - 4. For underground conduits entering or leaving a classified location or between Class I Division 1 and Division 2 locations:
    - a. Provide a conduit seal at both points where the conduit emerges from the ground:
      - 1) Place the conduit seal within 18 inches of finished grade.



- 2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.
  5. Separate all conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
    - a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.
  6. Install seals with drains in all electrical control stations, low points of conduit or any place where moisture may condense and accumulate.
  7. Install the sealing compound with a minimum thickness of 5/8 inch or the trade size of the conduit, whichever is greater.
- D. Boxes and fittings:
  1. Class I Division 1 areas:
    - a. Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.
  2. Class I Division 2 areas:
    - a. Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.
- E. Outlet boxes and bodies:
  1. Provide conduits bodies and boxes suitable for the conduit system as specified in Section 16130 - Conduits.
  2. Class I Division 2 areas:
    - a. Boxes not containing arcing parts:
      - 1) Material and NEMA ratings as specified in Section 16050 - Common Work Results for Electrical.
      - 2) Pressed metal boxes are not allowed.
    - b. Provide heavy duty cast construction type conduit fittings and joints:
      - 1) Explosion proof rated fittings and joints are not necessary.
    - c. Any enclosure containing arcing parts, etc. shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I Division 1 construction.
- F. Motor connections:
  1. Conduit installation in Class I Division 1 and Class I Division 2 locations for motors that contain arcing parts, shall proceed as follows:
    - a. First - Conduit.
    - b. Second - Explosion proof flexible coupling.
    - c. Third - Sealing fitting.
    - d. Fourth - Explosion proof union.
    - e. Fifth - Connection to the motor terminal box.
  2. Wiring connections to motor leads shall be as specified in Section 16150 - Low Voltage Wire Connections.
  3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**



**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Obtain inspection and approval from the Engineer before and after each seal is poured.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION (NOT USED)**

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## **SECTION 16060**

### **GROUNDING AND BONDING**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes: Grounding materials and requirements.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
  - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- D. Underwriters Laboratories, Inc. (UL):
  - 1. 467 - Ground and Bonding Equipment.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.04 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Catalog cut sheets.

##### **1.05 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All grounding components and materials shall be UL listed and labeled.

##### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.07 PROJECT/SITE CONDITIONS (NOT USED)**

### **1.08 SEQUENCING (NOT USED)**

### **1.09 SCHEDULING (NOT USED)**

### **1.10 WARRANTY**

A. As specified in Section 16050 - Common Work Results for Electrical.

### **1.11 SYSTEM START-UP**

A. As specified in Section 16050 - Common Work Results for Electrical.

### **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

### **1.13 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

A. Exothermic connectors: One of the following or equal:

1. Erico.
2. Harger.
3. Burndy.
4. Thomas & Betts.

B. Ground rods: One of the following or equal:

1. Erico.
2. Harger.
3. Nehring
4. Thomas & Betts.

C. Ground cable: One of the following or equal:

1. Erico.
2. Harger
3. Nehring.
4. Southwire.

D. Precast ground well boxes: One of the following or equal:

1. Brooks Products, 3-RT Valve Box.
2. Christy Concrete Products, G12 Valve Box.

### **2.02 SYSTEM DESCRIPTION**

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:

1. Grounding electrodes.





2. Bonding jumpers.
  3. Ground connections.
- C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
1. 5 ohms or less for industrial systems.

## **2.03 EXISTING PRODUCTS (NOT USED)**

## **2.04 MATERIALS**

- A. Ground rod:
1. Minimum: 3/4-inch diameter, 10 feet long.
  2. Uniform 10 mil covering of electrolytic copper metallicity bonded to a rigid steel core:
    - a. The copper-to-steel bond shall be corrosion resistant.
  3. In accordance with UL 467.
  4. Sectional type joined by threaded copper alloy couplings.
  5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
1. Requirements:
    - a. Soft drawn (annealed).
    - b. Concentric lay, coarse stranded in accordance with ASTM B8.
  2. Size is as indicated on the Drawings, but not less than required by the NEC.
- C. Exothermic welds:
1. Current carrying capacity equal to that of the conductor.
  2. Permanent molecular bond that cannot loosen or corrode over time.
  3. Will not deteriorate with age.
  4. Use low emission welds for indoor installations.
- D. Equipment grounding conductors:
1. Conductors shall be the same type and insulation as the load circuit conductors:
    - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
  2. Minimum size in accordance with the NEC.
- E. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.
- F. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

## **2.05 MANUFACTURED UNITS (NOT USED)**

## **2.06 EQUIPMENT (NOT USED)**



## **2.07 COMPONENTS (NOT USED)**

### **2.08 ACCESSORIES**

- A. Precast ground well boxes:
  - 1. Minimum 10 inch interior diameter.
  - 2. Traffic-rated cast iron cover.
  - 3. Permanent "GROUND" marking on cover.

### **2.09 MIXES (NOT USED)**

### **2.10 FABRICATION (NOT USED)**

### **2.11 FINISHES (NOT USED)**

### **2.12 SOURCE QUALITY CONTROL (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
  - 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
  - 2. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
  - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
  - 1. Individually bond these raceways to the ground bus in the equipment.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.



- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- H. Duct bank ground system:
  - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
  - 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- I. Grounding at service (600 V or Less):
  - 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- J. Ground connections:
  - 1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
  - 2. Make ground connections in accordance with the manufacturer's instructions.
  - 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
- K. Grounding electrode system:
  - 1. Ground ring:
    - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
    - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
    - c. Minimum burial depth 36 inches or as indicated on the Drawings.
    - d. Re-compact disturbed soils to original density in 6-inch lifts.
  - 2. Ground rods:
    - a. Locations as indicated on the Drawings.
    - b. Length of rods forming an individual ground array shall be equal in length.
    - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
  - 3. Metal underground water pipe:
    - a. Bond metal underground domestic water pipe to grounding electrode system.
  - 4. Metal frame of building or structure:
    - a. Bond metal frame of building or structure to grounding electrode system.
  - 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
  - 6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.
  - 7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.



- L. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
  2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
  3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
  4. Terminate the signal cable shield on a dedicated grounding terminal block.

M. Where indicated on the Drawings, install ground rods in precast ground wells.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

A. As specified in Section 01756 - Commissioning.

### **3.08 FIELD QUALITY CONTROL**

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

### **3.09 ADJUSTING**

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:

1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

### **3.10 CLEANING (NOT USED)**

### **3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16070

### HANGERS AND SUPPORTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Mounting and supporting electrical equipment and components.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - 3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SYSTEM DESCRIPTION

- A. Design requirements:
  - 1. Conform to the requirements of the Building Code as specified in Section 01410 - Regulatory Requirements.
  - 2. Demonstrate the following using generally accepted engineering methods:
    - a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
    - b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
  - 3. Design loading and anchoring requirements:
    - a. As indicated in the Building Code unless otherwise specified.
    - b. Seismic loading requirements:
      - 1) Freestanding, suspended or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050 - Common Work Results for Electrical.
    - c. Wind loading requirements:
      - 1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050 - Common Work Results for Electrical.
    - d. Minimum safety factor against overturning: 1.5.



- e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

B. Performance requirements:

- 1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

## 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:

- 1. Supports:
  - a. Materials.
  - b. Geometry.
  - c. Manufacturer.
- 2. Hardware:
  - a. Materials.
  - b. Manufacturer.

C. Shop drawings:

- 1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
- 2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, and wall supports for all equipment:
  - a. For free standing supports and wall supports supporting equipment weight in excess of 200 pounds:
    - 1) Stamped by a professional engineer licensed in the state where the Project is being constructed.
  - b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
- 3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation instructions:

- 1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
  - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

## 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM STARTUP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Preformed channel:
    - a. Thomas & Betts.
    - b. Power-Strut.
    - c. Unistrut.
    - d. Cooper B-Line.
    - e. Robroy.
    - f. Tyco.
- B. Nonmetallic cable rack:
  - 1. Underground Devices Inc.
  - 2. Hubbell.
  - 3. Unistrut.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.
- B. Preformed channel:
  - 1. Stainless steel:
    - a. Supports:
      - 1) In accordance with ASTM A240.
      - 2) ANSI Type 316 material.
    - b. Hardware:
      - 1) ANSI Type 316 material.



- C. Non-metallic cable rack:
1. Consists of stanchions and cable support arms.
  2. Stanchions:
    - a. 50 percent glass reinforced nylon or other non-metallic material.
    - b. Capable of supporting multiple arms.
    - c. Recessed bolt mounting holes.
    - d. Length as required.
  3. Arms:
    - a. 50 percent glass reinforced nylon or other non-metallic material.
    - b. Size the arms based on the length and weight of the cable to be supported.
  4. Stainless steel mounting hardware.

#### **2.04 MANUFACTURED UNITS (NOT USED)**

#### **2.05 EQUIPMENT (NOT USED)**

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES**

- A. Anchor bolts:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES**

- A. Paint and finish all supporting structures as specified in Section 09960 – High-Performance Coatings.

#### **2.11 SOURCE QUALITY CONTROL (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Preformed Channel:
1. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
    - a. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.





2. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
  - a. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
3. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
  - a. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
  - b. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
  - c. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
  - 1) Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
5. Corrosion protection:
  - a. Isolate dissimilar metals, except where required for electrical continuity.
    - 1) Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
6. Raceway:
  - a. Furnish all racks and trapeze structures needed to support the raceway from the structure.
    - 1) Group raceway and position on racks to minimize crossovers.
    - 2) Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
7. Anchoring methods:
  - a. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
  - b. Metal surfaces: Machine screws or bolts.
  - c. Hollow masonry units: Post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
8. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.
9. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

C. Non-metallic cable rack:

1. Install the non-metallic cable rack in accordance with the manufacturer's recommendations.
2. Provide at least 2 stanchions and 2 arms at each installation.
3. Mount the cable rack so that the supported cable does not interfere with access to manhole or handhole and so that the supported cable does not lie on the floor.
4. Do not exceed the cable manufacturer's minimum bending radius.
5. Use nylon cable ties to secure the cable to the supports.



**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16075

### IDENTIFICATION FOR ELECTRICAL SYSTEMS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Identification of electrical equipment, devices and components.
  - 2. Material, manufacturing and installation requirements for identification devices.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Occupational Safety and Health Administration (OSHA).

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SYSTEM DESCRIPTION

- A. Nameplates:
  - 1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
  - 2. Provide all nameplates of identical style, color, and material throughout the facility.
  - 3. Device nameplates information:
    - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
- B. Wire numbers:
  - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
    - a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
    - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
    - c. Internal panel wires on a common terminal shall have the same wire number.
    - d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
      - 1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130 - Conduits.



2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)-(ORIGIN TERM.)/(DEST. LOC.)-(DEST. TERM.)

OR

(ORIGIN LOC.)-(ORIGIN TERM.)  
(DEST. LOC.)-(DEST. TERM.)

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

I/O address at destination panel:

- a. Identify equipment and field instruments as the origin.
- b. PCMs are always identified as the destination.
- c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
- d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
- e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
- f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
  - 1) Discrete Point: W:X:Y/Z.  
Analog Point: W:X:Y.Z.  
Where:  
W= I for input, O for output  
X= PLC number (1, 2, 3...)  
Y= Slot number (01, 02, 03...)  
Z= Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
- g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).



3. **Case 1:** Vendor control panel (VCP) to process control module (PCM):  
Field wire number/label: A-B/C-D  
A = Vendor control panel number without hyphen (VCP#)  
B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)  
C = Process control module number without hyphen (PCM#)  
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I: 1:01/01  
VCP#-10/PCM#-O: 1:10/07  
VCP#-10/PCM#-C0100

4. **Case 2:** Field instrument to process control module (PCM):  
Field wire number/label: E-F/C-D  
C = Process control module number without hyphen (PCM#)  
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)  
E = Field mounted instrument tag and loop numbers without hyphen (EDV#)  
F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples: TIT#-2,3/PCM#-I: 1:01.1  
TSH#-1/PCM#-I: 2:01/00

5. **Case 3:** Motor control center (MCC) to process control module (PCM):  
Field wire number/label: G-B/C-D  
B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)  
C = Process control module without hyphen (PCM#)  
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)  
G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples: MMS#-10/PCM#-I: 1:01/01  
MMS#-10/PCM#-O: 1:10/07  
MMS#-10/PCM#-C0100

6. **Case 4:** Motor control center (MCC) to vendor control panel (VCP):  
Field wire number/label: G-B/A-B  
A = Vendor control panel number without hyphen (VCP#)  
B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)  
G = Actual starter designation in the motor control center without hyphen (MMS#)

Example: MMS#-X2/VCP#-10



7. **Case 5:** Motor leads to a motor control center (MCC):  
Field wire number/label: H-I/G-B  
B = Terminal number within motor control center (manufacturer's standard terminal number)  
G = Actual starter designation in the motor control center without hyphen (MMS#)  
H = Equipment tag and loop number without hyphen (PMP#)  
I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)

Example: PMP-#-T3/MMS#-T3

8. Identify all spare conductors as required for other field wires with an "S" prefix:

Example: S MMS#-10/PCM#-C011

### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
1. Nameplates:
    - a. Color.
    - b. Size:
      - 1) Outside dimensions.
      - 2) Lettering.
    - c. Material.
    - d. Mounting means.
  2. Nameplate schedule:
    - a. Show exact wording for each nameplate.
    - b. Include nameplate and letter sizes.
  3. Wire numbers:
    - a. Manufacturer's catalog data for wire labels and label printer.
- C. Record documents:
1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

### 1.06 QUALITY ASSURANCE (NOT USED)

### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

### 1.08 PROJECT SITE CONDITIONS (NOT USED)

### 1.09 SEQUENCING (NOT USED)

### 1.10 SCHEDULING (NOT USED)

### 1.11 WARRANTY



- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Nameplates and signs:
  - 1. One of the following or equal:
    - a. Brady.
    - b. Seton.
- B. Conductor and cable markers:
  - 1. Heat-shrinkable tubing:
    - a. One of the following or equal:
      - 1) Raychem.
      - 2) Brady.
      - 3) Thomas & Betts.
      - 4) Kroy.
  - 2. Non heat-shrinkable tubing:
    - a. One of the following or equal:
      - 1) Brady.
      - 2) Seton.
  - 3. Pre-printed slip-on sleeve markers:
    - a. The following or equal: Engineer knows of no equal.
      - 1) Grafoplast.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Nameplates:
  - 1. Colors:
    - a. Warning nameplates: White-center, red face.
    - b. Other nameplates: Black-center, white face.
  - 2. Laminated plastic engraving stock:
    - a. 3/32-inch thick material.
    - b. 2-ply.
    - c. With chamfered edges.
  - 3. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
    - a. No characters smaller than 1/8-inch in height.



- B. Signs:
  - 1. Automatic equipment and high voltage signs:
    - a. Suitable for exterior use.
    - b. In accordance with OSHA regulations.
- C. Conductor and cable markers:
  - 1. Machine printed black characters on white tubing.
  - 2. 10 point type or larger.

#### **2.04 MANUFACTURED UNITS (NOT USED)**

#### **2.05 EQUIPMENT (NOT USED)**

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES (NOT USED)**

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES (NOT USED)**

#### **2.11 SOURCE QUALITY CONTROL**

- A. Nameplates:
  - 1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
    - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Nameplates:
  - 1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
  - 2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
  - 3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
    - a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.





- C. Conductor and cable markers:
  - 1. Apply all conductor and cable markers before termination.
  - 2. Non heat-shrinkable tubing:
    - a. Tubing shall be sized for the wire and insulation on which it is to be placed.
    - b. Tubing shall be tight on the wire.
    - c. Characters shall face the open panel and shall read from left to right or top to bottom.
    - d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
- D. Signs and labeling:
  - 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
    - a. Fasten warning signs with round head stainless steel screws or bolts.
    - b. Locate and mount in a manner to be clearly legible to operations personnel.
  - 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
  - 3. Furnish and install warning signs on equipment that has more than one source of power.
    - a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
  - 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
    - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

- A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.



3.09 **ADJUSTING (NOT USED)**

3.10 **CLEANING (NOT USED)**

3.11 **PROTECTION (NOT USED)**

3.12 **SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16123

### 600-VOLT OR LESS WIRES AND CABLES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. 600 volt class or less wire and cable.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
  - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. CSA International (CSA).
- D. Insulated Cable Engineers Association (ICEA):
  - 1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
  - 2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
- E. National Fire Protection Association (NFPA):
  - 1. 72 - National Fire Alarm and Signaling Code.
  - 2. 101 - Life Safety Code.
- F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
  - 1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
  - 2. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.
  - 3. 1005 - Industrial Cabling Standard.
- G. Underwriter's Laboratories Inc., (UL):
  - 1. 44 - Thermoset-Insulated Wires and Cables.
  - 2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
  - 3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
  - 4. 1569 - Standard for Metal-Clad Cables.
  - 5. 2196 - Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
  - 6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.



### 03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
  - 1. AWG: American wire gauge.
  - 2. BCCS: Bare copper-covered steel.
  - 3. CPE: Chlorinated polyethylene.
  - 4. FEP: Fluorinated ethylene propylene.
  - 5. FHDPE: Foam high-density polyethylene.
  - 6. FPE: Foam polyethylene.
  - 7. OD: Outside diameter.
  - 8. PVC: Polyvinyl chloride.
  - 9. XHHW: Cross-linked high heat water resistant insulated wire.
- C. Definitions of terms and other electrical considerations as set forth in the:
  - 1. ASTM.
  - 2. ICEA.

### 1.04 SYSTEM DESCRIPTION

- A. Furnish and install the complete wire and cable system.

### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer of wire and cable.
  - 2. Insulation:
    - a. Type.
    - b. Voltage class.
  - 3. AWG size.
  - 4. Conductor material.
  - 5. Pulling compounds.
- C. Shop drawings:
  - 1. Show splice locations.
    - a. For each proposed splice location provide written justification describing why the splice is necessary.
- D. Test reports:
  - 1. Submit test reports for meg-ohm tests.
- E. Calculations:
  - 1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
    - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.



- b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All wires and cables shall be UL listed and labeled.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER`S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. 600 volt class wire and cable:
    - a. General Cable.
    - b. Okonite Co.
    - c. Southwire Co.
    - d. Service Wire.
  - 2. 600 volt VFD cable:
    - a. General Cable.
    - b. Southwire Co.
    - c. Service Wire.
  - 3. Instrumentation class wire and cable:
    - a. Alpha Wire Co.
    - b. Belden CDT.
    - c. General Cable.
    - d. Okonite Co.
    - e. Rockbestos Surprenant Cable Corp.



4. Network cables:
  - a. General Cable.
  - b. Belden.
  - c. CommScope.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Conductors:
  1. Copper in accordance with ASTM B3.

## **2.04 MANUFACTURED UNITS**

- A. General:
  1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
  2. Permanently mark each wire and cable with the following at 24-inch intervals:
    - a. AWG size.
    - b. Voltage rating.
    - c. Insulation type.
    - d. UL symbol.
    - e. Month and year of manufacture.
    - f. Manufacturer's name.
  3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
    - a. Use integral color insulation for #2 AWG and smaller wire.
    - b. Wrap colored tape around cable larger than #2 AWG.
- B. 600 volt class wire and cable:
  1. Provide AWG or kcmil sizes as indicated on the Drawings:
    - a. When not indicated on the Drawings, size wire as follows:
      - 1) In accordance with the NEC:
        - a) Use 75 degree Celsius ampacity ratings.
        - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
      - 2) Provide #12 AWG minimum for power conductors.
      - 3) Provide #14 AWG minimum for control conductors.
  2. Provide Class B stranding in accordance with ASTM B8:
    - a. Provide Class C stranding where extra flexibility is required.
  3. Insulation:
    - a. XHHW-2.
    - b. 90 degree Celsius rating.
- C. 600 volt VFD cables:
  1. Conductor:
    - a. Provide Class B stranding in accordance with ASTM B8.
  2. Insulation:
    - a. Cross-linked Polyethylene.
    - b. 90 degree Celsius rating.
    - c. UL 44 Type RHH/RHW-2 or XHHW-2.
  3. Ground:
    - a. Provide Class B stranding in accordance with ASTM B8.



- b. 3 symmetrically placed bare copper conductors in direct contact with shield.
  - 4. Metallic shield:
    - a. Overall 5 mil bare copper tape shield with 50 percent overlap.
  - 5. Outer jacket:
    - a. UL 1277 Type PVC.
  - 6. Cable tray rated, UL Type TC-ER.
- D. Instrumentation class cable:
  - 1. Type TC.
  - 2. Suitable for use in wet locations.
  - 3. Voltage rating: 600 volts.
  - 4. Temperature rating:
    - a. 90 degree Celsius rating in dry locations.
    - b. 75 degree Celsius rating in wet locations.
  - 5. Conductors:
    - a. Insulation:
      - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
    - b. #16 AWG stranded and tinned.
    - c. Color code: ICEA Method 1:
      - 1) Pair: Black and white.
      - 2) Triad: Black, white and red.
      - 3) Multiple pairs or triads:
        - a) Color-coded and numbered.
  - 6. Drain wire:
    - a. #18 AWG.
    - b. Stranded, tinned.
  - 7. Jacket:
    - a. Flame retardant, moisture and sunlight resistant PVC.
    - b. Ripcord laid longitudinally under jacket to facilitate removal.
  - 8. Shielding:
    - a. Individual pair/triad:
      - 1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
    - b. Multiple pair or triad shielding:
      - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
      - 2) Completely isolate group shields from each other.
      - 3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    - c. All shielding to be in contact with the drain wire.
- E. Network cables:
  - 1. Category 6:
    - a. General:
      - 1) Provide Cat 6 cables meeting the standards set by TIA/EIA-568-C.2 and verified by third-party testing laboratory.
    - b. Conductors:
      - 1) #23 AWG solid bare annealed copper.
      - 2) 4 Bonded pairs.



- c. Drain wire:
  - 1) #24 AWG stranded (7/32) tinned copper.
- d. Insulation:
  - 1) Non-Plenum: Polyolefin.
  - 2) Plenum: Fluoropolymer.
- e. Shielding:
  - 1) None.
  - 2) Overall Foil Shield.
- f. Color code:
  - 1) Pair 1: White/blue stripe and blue.
  - 2) Pair 2: White/orange stripe and orange.
  - 3) Pair 3: White/green stripe and green.
  - 4) Pair 4: White/brown stripe and brown.
- g. Outer jacket:
  - 1) Non-Plenum: Flame-Retardant PVC.
  - 2) Plenum: Low-Smoke, Flame-Retardant PVC.
- h. Electrical characteristics:
  - 1) Voltage rating: 600VAC.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS (NOT USED)**

## **2.07 ACCESSORIES**

- A. Wire ties:
  - 1. One of the following or equal:
    - a. T&B, "Ty-Rap" cable ties.
    - b. Panduit, cable ties.
- B. Wire markers:
  - 1. As specified in Section 16075 - Identification for Electrical Systems.

## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES (NOT USED)**

## **2.11 SOURCE QUALITY CONTROL**

- A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.
- B. Test Type XHHW-2 in accordance with the requirements of UL 44.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**





### 3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Color-coding:
  - 1. Color-coding shall be consistent throughout the facility.
  - 2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Single phase system: Black for 1 hot leg, red for the other.
    - e. Neutral: White.
    - f. High phase or wild leg: Orange.
    - g. Equipment ground: Green.
  - 3. The following color code shall be followed for all 480/277 volt systems:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
    - d. Neutral: Gray.
    - e. Equipment ground: Green.
  - 4. The following color code shall be followed for all 120 VAC control wiring:
    - a. Power: Red.
    - b. Neutral: White.
  - 5. The following color code shall be followed for all general purpose DC control circuits:
    - a. Grounded conductors: White with blue stripe.
    - b. Ungrounded conductors: Blue.
  - 6. Switch legs shall be violet. 3-way switch runners shall be pink.
  - 7. Wires in intrinsically safe circuits shall be light blue.
  - 8. Wire colors shall be implemented in the following methods:
    - a. Wires manufactured of the desired color.
    - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
      - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
  - 1. Install wires only in approved raceways.
  - 2. Do not install wire:
    - a. In incomplete conduit runs.
    - b. Until after the concrete work and plastering is completed.
- D. Properly coat wires and cables with pulling compound before pulling into conduits:
  - 1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
    - a. Ideal Products.
    - b. Polywater Products.
    - c. 3M Products.
    - d. Greenlee Products.
    - e. Or equal as recommended by cable manufacturer.



f. Do not use oil, grease, or similar substances.

E. Cable pulling:

1. Prevent mechanical damage to conductors during installation.
2. For cables #1 AWG and smaller, install cables by hand.
3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
  - a. Make splices in manholes or pull boxes only.
  - b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:

1. Do not lace wires in gutter or panel channel.
2. Install all wire ties with a flush cutting wire tie installation tool:
  - a. Use a tool with an adjustable tension setting.
3. Do not leave sharp edges on wire ties.

I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:

1. Use ring type lugs if box lugs are not available on the equipment.

J. Lighting circuits:

1. Each circuit shall have a dedicated neutral.

K. Splices:

1. Provide continuous circuits from origin to termination whenever possible:
  - a. Obtain Engineer's approval prior to making any splices.
2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
  - a. Splice box NEMA rating requirements as specified in Section 16050 - Common Work Results for Electrical.
  - b. Make splices in labeled junction boxes for power conductors.
  - c. Make splices for control and instrument conductors in terminal boxes:
    - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
4. Power and control conductors routed in common raceways may be spliced in common junction boxes.



5. Clearly label junction and terminal boxes containing splices with the word "SPlice LOCATED WITHIN".
  6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
  7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
    - a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
  8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
    - a. A heat shrink insulating system listed for submersible applications.
    - b. Or an epoxy resin splicing kit.
- L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.
- M. Instrumentation class cable:
1. Install instrumentation class cables in separate raceway systems from power cables:
    - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
    - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
  2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
  3. Shield grounding requirements as specified in Section 16060 - Grounding and Bonding.
- N. Copper Ethernet cables:
1. Comply with TIA/EIA-568-C.2.
  2. Pathways:
    - a. For initial installation, the maximum fill capacity for pathways (i.e. conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
    - b. Conduit should be run in the most direct route possible with no more than two 90 degree bends between pull boxes and serve no more than 3 outlet boxes.
  3. Cable bend radius:
    - a. Proper cable bend radius control must be maintained throughout the pathways. The bend radius needs to be at a minimum 10 times the cable diameter.
  4. Cable pulling:
    - a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
    - b. The maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
    - c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.



5. Cable management:
  - a. Organize and manage cables for quick and easy moves, adds and changes.
6. Testing:
  - a. All cables and termination hardware shall be 100 percent tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of TIA/EIA-568-C.1 Section 11.
    - 1) All pairs of each installed cable shall be verified prior to system acceptance.
    - 2) Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed.
  - b. All twisted-pair copper cable links shall be tested for compliance to the requirements in TIA/EIA/568-C.2 for the appropriate Category of cabling installed.
  - c. All cables shall be tested in accordance with the contract documents, TIA/EIA standards, and best industry practice.
  - d. The field test equipment shall meet the requirements of TIA/EIA-568-C. The appropriate level III tester shall be used to verify Category 6 cabling.
  - e. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-C.1.
  - f. Visually inspect cable placement, cable termination, grounding and bonding, equipment and labeling of all components.
  - g. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors.
    - 1) Test operation of shorting bars in connection blocks.
    - 2) Test cables after termination but not cross-connection.
      - a) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.2.
        - (1) Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
        - (2) Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
7. Separation from EMI sources:
  - a. Comply with TIA/EIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.



- 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches
  - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
  - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
  - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
- O. Signal cable:
  - 1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.
- P. Wiring allowances:
  - 1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
  - 2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Grounding:
  - 1. As specified in Section 16060 - Grounding and Bonding.



3.09 **ADJUSTING (NOT USED)**

3.10 **CLEANING (NOT USED)**

3.11 **PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 **SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16130

### CONDUITS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Metallic conduits.
  - 2. Nonmetallic conduits.
  - 3. Conduit bodies.
  - 4. Conduit fittings and accessories.
  - 5. Conduit installation.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American National Standards Institute (ANSI):
  - 1. C80.1 - Electrical Rigid Steel Conduit.
  - 2. C80.3 - Steel Electrical Metallic Tubing.
  - 3. C80.5 - Electrical Rigid Aluminum Conduit.
  - 4. C80.6 - Electrical Intermediate Metal Conduit.
- C. National Electrical Manufacturer's Association (NEMA):
  - 1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
  - 2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
  - 3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
  - 4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
  - 5. TC13 - Electrical Nonmetallic Tubing.
  - 6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- D. Underwriters Laboratories (UL):
  - 1. 1 - Standard for Flexible Metal Conduit.
  - 2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
  - 3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
  - 4. 360 - Standard for Liquidtight Flexible Steel Conduit.
  - 5. 651 - Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
  - 6. 651B - Standard for Continuous Length HDPE Conduit.
  - 7. 797 - Standard for Electrical Metallic Tubing - Steel.
  - 8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
  - 9. 1653 - Standard for Electrical Nonmetallic Tubing.
  - 10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.
  - 11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.





## **DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
  - 1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
  - 2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
  - 3. GRC: Galvanized rigid steel conduit.
  - 4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
  - 5. EMT: Electrical metallic tubing.
  - 6. PVC: Polyvinyl chloride rigid nonmetallic conduit.
  - 7. SLT: Sealtight-liquidtight flexible conduit.
  - 8. EFLX: Explosion proof flexible conduit.
  - 9. RAC: Rigid aluminum conduit.
  - 10. NPT: National pipe thread.

## **1.04 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
  - 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
- C. Certifications:
  - 1. Furnish PVC-coated conduit manufacturer's certification for each installer.
- D. Record Documents:
  - 1. Incorporate all changes in conduit routing on electrical plan drawings.
  - 2. Dimension underground and concealed conduits from building lines.
  - 3. Furnish hard copy drawings.

## **1.05 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.
- C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Do not expose non-metallic conduit to direct sunlight.





- C. Do not store conduit in direct contact with the ground.
- D. Do not store aluminum conduit in contact with concrete.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 SEQUENCING**

- A. Before installing any conduit or locating any device box:
  - 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
  - 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

## **1.09 SCHEDULING (NOT USED)**

## **1.10 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.11 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.13 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Galvanized rigid steel conduit:
  - 1. One of the following or equal:
    - a. Western Tube and Conduit.
    - b. Allied Tube and Conduit.
    - c. Wheatland Tube Co.
- B. PVC-coated rigid steel conduit:
  - 1. One of the following or equal:
    - a. Robroy Ind.
    - b. Ocal, Inc.
    - c. Calbond.
    - d. Allied.
    - e. NEC, Inc. BlackGuard.
- C. Sealtight-liquidtight flexible conduit:
  - 1. One of the following or equal:
    - a. Southwire.



- b. AFC Cable Systems.
    - c. Electri-Flex Co.
    - d. Anaconda.
- D. Explosion proof flexible conduit:
  - 1. One of the following or equal:
    - a. Appleton.
    - b. Crouse-Hinds.
    - c. Hubbell Killark.
- E. Conduit bodies:
  - 1. One of the following or equal:
    - a. Crouse-Hinds.
    - b. Appleton.
    - c. O-Z/Gedney.
    - d. Ocal, Inc.
    - e. Robroy Ind.
    - f. Calbond.
    - g. Carlon.
- F. Joint compound:
  - 1. The following or equal:
    - a. Thomas and Betts.
- G. Galvanized rigid steel conduit expansion fittings:
  - 1. One of the following or equal:
    - a. Crouse-Hinds.
    - b. Appleton.
    - c. O-Z/Gedney.
- H. PVC-coated rigid steel conduit expansion fittings:
  - 1. One of the following or equal:
    - a. Ocal, Inc.
    - b. Robroy Ind.
    - c. NEC, Inc. BlackGuard.
- I. Conduit sleeve:
  - 1. One of the following or equal:
    - a. Crouse-Hinds.
    - b. Appleton.
    - c. O-Z/Gedney.
- J. Conduit seals:
  - 1. One of the following or equal:
    - a. Appleton.
    - b. Crouse-Hinds.
    - c. O-Z/Gedney.
- K. Conduit hangers and supports:
  - 1. As specified in Section 16070 - Hangers and Supports.
- L. Conduit through wall and floor seals:
  - 1. The following or equal:



- a. O-Z/Gedney:
  - 1) Type "WSK."
  - 2) Type "CSM."

## **2.02 SYSTEM DESCRIPTION**

- A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

## **2.03 EXISTING PRODUCTS (NOT USED)**

## **2.04 MATERIALS (NOT USED)**

## **2.05 MANUFACTURED UNITS (NOT USED)**

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS**

- A. GRC:
  - 1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
    - a. Running conduit threads are not acceptable.
  - 2. Hot-dip galvanized inside and out:
    - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
    - b. Electro-galvanizing is not acceptable.
  - 3. Manufactured in accordance with:
    - a. UL-6.
    - b. ANSI C80.1.
- B. PCS:
  - 1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
  - 2. Coated conduit NEMA Standard RN-1:
    - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
  - 3. Factory-bonded PVC jacket:
    - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
    - b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
    - c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
    - d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
      - 1) Confirm bond with certified test results.
  - 4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
    - a. Nominal thickness of 0.002 inch.
    - b. Conduits having areas with thin or no coating are not acceptable.



- c. All threads shall be coated with urethane.
  5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
  6. PCS conduit bodies and fittings:
    - a. Malleable iron.
    - b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
    - c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
    - d. 0.002-inch interior urethane coating.
    - e. Utilize the PVC coating as an integral part of the gasket design.
    - f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
    - g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
      - 1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
      - 2) The sleeve shall provide a vapor- and moisture resistant seal at every connection.
- C. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    - a. General purpose:
      - 1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
    - b. Oil-resistant:
      - 1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
  2. Sunlight-resistant, weatherproof, and watertight.
  3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
  4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
  5. Overall PVC jacket.
  6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.
- D. EFLX:
1. Suitable for the hazardous Class and Group where installed:
    - a. As specified in Section 16050 - Common Work Results for Electrical.
  2. Metallic braid shall provide continuous electrical path.
  3. Stainless steel construction.
  4. Provide fittings and unions as required for the installation.
- E. PVC:
1. Extruded from virgin PVC compound:
    - a. Schedule 40 unless otherwise specified.
    - b. Schedule 80 extra-heavy wall where specified.
  2. Rated for 90 degrees Celsius conductors or cable.
  3. Rated for use in direct sunlight.



- F. Conduit bodies:
  - 1. Material consistent with conduit type:
    - a. Malleable iron bodies and covers when used with Type GRC.
    - b. Cast aluminum bodies and covers when used with Type RAC.
    - c. PVC bodies and covers when used with Type PVC.
    - d. PVC-coated malleable iron bodies and covers when used with Type PCS.
  - 2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
    - a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
  - 3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

## **2.08 ACCESSORIES**

- A. Connectors and fittings:
  - 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:
  - 1. Construction:
    - a. Malleable iron or zinc-plated steel when used with steel conduit.
    - b. Aluminum when used with aluminum conduit.
    - c. Positive metallic conduit end stop.
    - d. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    - e. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.
- C. Insulated grounding bushings:
  - 1. Construction:
    - a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
    - b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
    - c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.
- D. Electrical unions (Erickson Couplings):
  - 1. Construction:
    - a. Malleable iron for use with steel conduit.
    - b. Aluminum for use with aluminum conduit.
    - c. Concrete tight, 3-piece construction.
    - d. Rated for Class I Division 1 Group D in hazardous areas.
- E. SLT fittings:
  - 1. Construction:
    - a. Malleable iron.
    - b. Furnished with locknut and sealing ring.
    - c. Liquidtight, raintight, oiltight.
    - d. Insulated throat.
    - e. Furnish as straight, 45-degree elbows, and 90-degree elbows.



- f. Designed to prevent sleeving:
        - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
      - g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
      - h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
    - 2. Corrosion-resistant and outdoor SLT fittings:
      - a. Construction:
        - 1) PVC-coated liquidtight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
        - 2) Insulated throat and an integral sealing ring.
- F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
  - 1. Construction:
    - a. Insulated throat.
    - b. PVC-coated when used in corrosive areas.
    - c. Bonding locknut.
    - d. Recessed neoprene o-ring to ensure watertight and dusttight connector.
    - e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
    - f. 1-1/2-inch through 6-inch malleable iron zinc plated.
    - g. Aluminum with aluminum conduit.
  - 2. Usage:
    - a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- G. Sealing fittings:
  - 1. Construction:
    - a. 40-percent wire fill capacity.
    - b. PVC-coated when used in corrosive areas.
    - c. Malleable ductile iron with steel conduit.
    - d. Aluminum with aluminum conduit.
    - e. Type EYDX where drains are required.
    - f. Type EYSX where drains are not required.
    - g. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.
  - 2. Sealing compound:
    - a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
    - b. Approved for the conditions and use.
      - 1) Not affected by surrounding atmosphere or liquids.
    - c. Melting point shall be 200 degrees Fahrenheit minimum.



- H. PVC fittings:
  - 1. Materials:
    - a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
    - b. All metal hardware shall be stainless steel.
- I. Through wall and floor seals:
  - 1. Materials:
    - a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish Aluminum.
    - b. Grommet: Neoprene.
    - c. Pressure rings: PVC-coated steel.
    - d. Disc material: PVC-coated steel.
- J. Expansion/deflection couplings:
  - 1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
  - 2. Shall allow movement of 3/4 inch from the normal in all directions.
  - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
  - 4. Constructed to maintain electrical continuity of the conduit system.
  - 5. Materials:
    - a. End couplings: Bronze or galvanized ductile iron.
    - b. Sleeve: Neoprene.
    - c. Bands: Stainless steel.
    - d. Bonding jumper: Tinned copper braid.
- K. Expansion couplings:
  - 1. Shall allow for expansion and contraction of conduit:
    - a. Permitting 8-inch movement, 4 inches in either direction.
  - 2. Constructed to maintain electrical continuity of the conduit system.
  - 3. Materials:
    - a. Head: Malleable or ductile iron.
    - b. Sleeve: Steel.
    - c. Insulating bushing: Phenolic.
    - d. Finish: Hot-dip galvanized.
    - e. Aluminum when used with Type RAC.
    - f. PVC-coated when used with Type PCS.
- L. Conduit markers:
  - 1. As specified in Section 16075 - Identification for Electrical Systems.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **ART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
  - 1. Conduit routing:
    - a. The electrical drawings are diagrammatic in nature:
      - 1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
      - 2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
        - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
        - b) Make changes in conduit routing due to the relocation of equipment.
      - 3) The electrical drawings do not indicate all required junction boxes and pull boxes:
        - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
          - (1) To meet cable manufacturer's pulling tension requirements.
          - (2) To limit total conduit bends between pull locations.
        - b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
    - b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
      - 1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
      - 2) Perform any changes resulting in additional conduits, or extra work from such deviations.
      - 3) Incorporate any deviations on the Record Documents.
  - 2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
  - 3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
    - a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
    - b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
    - c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
    - d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.





4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
    - a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
  5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
  6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
    - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
    - b. Make changes in direction with long radius bends or with conduit bodies.
  7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
  8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
    - a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
    - b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
  9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
  10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
  11. Install conduits through wall and floor seals where indicated on the Drawings.
  12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    - a. Remove and replace conduits through which mandrel will not pass.
  13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
  14. Install complete conduit systems before conductors are installed.
  15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
  16. Underground conduits:
    - a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
      - 1) As specified in Section 16133 - Duct Banks.
    - b. Make underground conduit size transitions at handholes and manholes.
    - c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    - d. Seal around conduit penetrations of below grade walls with a mechanical seal.
- C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:



2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
  3. Minimum conduit size:
    - a. 3/4-inch for exposed conduits.
    - b. 1-inch for underground or in-slab conduits.
  4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.
- D. Hazardous areas:
1. As specified in Section 16050 - Common Work Results for Electrical for hazardous areas and specific Class and Division.
  2. As specified in Section 16052 - Hazardous Classified Area Construction for hazardous area conduit installation requirements.
- E. Conduit usage:
1. Exposed conduits:
    - a. Rigid conduit:
      - 1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
      - 2) Minimum size: 3/4-inch.
    - b. Flexible conduit:
      - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
        - a) Use Type SLT with rigid metallic conduit.
        - b) Use Type EFLX in Class I Division 1 locations.
      - 2) Minimum size: 3/4-inch:
        - a) 1/2 when required for connection to instruments.
      - 3) Maximum length:
        - a) Fixed equipment:
- | Conduit Trade Size | Flexible Conduit Length (inch) |
|--------------------|--------------------------------|
| 3/4                | 18                             |
| 1                  | 18                             |
| 1-1/4              | 18                             |
| 1-1/2              | 18                             |
| 2                  | 36                             |
| 2-1/2              | 36                             |
| 3                  | 36                             |
| 3-1/2              | 38                             |
| 4                  | 40                             |
- b) Removable instruments or hinged equipment:
    - (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.



2. Concrete-encased and embedded conduits:
  - a. Straight runs and bends less than 45 degrees:
    - 1) Type PVC Schedule 40.
  - b. Bends with total deflection greater than 45 degrees;
    - 1) PCS,
  - c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
    - 1) PCS.
  - d. Minimum size:
    - 1) 2-inch in duct banks.
    - 2) 1-inch for in-slab conduits.
    - 3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.
3. Direct-buried and sand-bedded duct bank conduits:
  - a. Type PCS.
  - b. Minimum size: 1-inch.
4. Below-slab conduits:
  - a. Type PCS.
  - b. Minimum size: 1-inch.
5. PVC-coated rigid metallic conduit:
  - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
6. GRC:
  - a. Conduit shall be cut square and reamed before threading.

F. Conduit joints and bends:

1. General:
  - a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
  - b. Keep bends and offsets in conduit runs to an absolute minimum.
  - c. All bends shall be symmetrical.
  - d. The following conduit systems shall use large-radius sweep elbows:
    - 1) Underground conduits.
    - 2) Conduits containing fiber optic cables.
  - e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
  - f. Make field bends with a radius of not less than the requirements found in the NEC:
    - 1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
    - 2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
      - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
      - b) For the serving utilities, make bends to meet their requirements.
  - g. Replace all deformed, flattened, or kinked conduit.
2. Threaded conduit:
  - a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the



couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.

- b. Thoroughly ream conduit after threads have been cut to remove burrs.
  - c. Use bushings or conduit fittings at conduit terminations.
  - d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It."
  - e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
    - 1) Apply to the male threads and tighten joints securely.
    - 2) Clean excess sealant from exposed threads after assembly.
  - f. Securely tighten all threaded connections.
  - g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
3. PVC:
- a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
  - b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
    - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit sealing and drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas:
  - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
  - b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
  - c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
    - 1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
  - d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
  - e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.

H. Conduit supports:

1. General:
  - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
    - 1) As specified in Section 16070 - Hangers and Supports.



- 2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
        - b. Support conduit at the intervals required by the NEC.
        - c. Perforated strap and plumbers tape are not acceptable for conduit supports.
    2. Conduit on concrete or masonry:
      - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      - b. Use preset inserts in concrete when possible.
      - c. Use pipe spacers (clamp backs) in wet locations.
    3. Suspended conduit:
      - a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
      - b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
    4. Supports at structural steel members:
      - a. Use beam clamps.
      - b. Drilling or welding may be used only as specified or with approval of the Engineer.
    5. PVC-coated rigid metal systems:
      - a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
      - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.
  - I. Expansion or expansion/deflection fittings:
    1. General:
      - a. Align expansion coupling with the conduit run to prevent binding.
      - b. Follow manufacturer's instructions to set the piston opening.
      - c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      - d. Furnish fittings of the same material as the conduit system.
    2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
      - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
  - J. Empty conduits:
    1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
    2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
      - a. Keep ends sealed until immediately before pulling conductors.



K. Miscellaneous:

1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
  - a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab, per the Typical Details.

**3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## **SECTION 16133**

### **DUCT BANKS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Electrical underground duct banks.
  - 2. Duct bank installation requirements.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.04 SYSTEM DESCRIPTION**

- A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. PVC conduit spacers.
  - 2. Detectable underground marking tape.
  - 3. Pull line.
- C. Provide applicable submittal documents as specified in:
  - 1. Section 02318 - Trenching.
  - 2. Section 03200 - Concrete Reinforcing.
  - 3. Section 03300 - Cast-In-Place Concrete.
- D. Shop drawings:
  - 1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.



2. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
  - a. Submit shop drawings detailing the new building footer crossing locations and plan drawings labeling all equipment to be installed on top of the new routing for approval by the project Structural Engineer.

#### **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.09 SEQUENCING**

#### **1.10 SCHEDULING (NOT USED)**

#### **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.14 MAINTENANCE (NOT USED)**

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Conduit spacers:
  1. One of the following or equal:
    - a. Carlon Snap-Loc.
    - b. Cantex.
    - c. Osburn Associates, Inc.
- B. Detectable underground marking tape:
  1. One of the following or equal:
    - a. Blackburn Manufacturing Co.
    - b. Pro-Line Safety Products.
    - c. Panduit.
- C. Pull line:
  1. One of the following or equal:





- a. Arnco.
- b. Greenlee.
- c. Osburn Associates, Inc.

- D. Duct seal:
  - 1. The following or equal:
    - a. OZ Gedney type DUX.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS**

- A. Provide conduit as specified in Section 16130 – Conduits:
  - 1. Use duct suitable for use with 194 degree Fahrenheit rated conductors.
- B. Provide reinforcing steel as specified in Section 03200 - Concrete Reinforcing:
  - 1. Provide minimum Number 4 reinforcing steel.

## **2.04 MANUFACTURED UNITS**

- A. Conduit spacers:
  - 1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
  - 2. Saddle type.
  - 3. Non-metallic, non-corrosive, non-conductive.
  - 4. Interlocking type:
    - a. Vertical interlocking.
    - b. Horizontal interlocking.
  - 5. Suitable for concrete encasement.
  - 6. Molded-in rebar holder.
  - 7. Accommodates 2-inch through 6-inch conduit sizes.
  - 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull line:
  - 1. Minimum 1/4-inch wide, flat design.
  - 2. Polyester.
  - 3. Minimum pulling strength 1,200 pounds.
- C. Detectable marking tape:
  - 1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
  - 2. Aluminum core laminated between polyethylene film.
  - 3. 6-inch wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW" or equivalent.
- D. Duct seal:
  - 1. Non-hardening sealing compound.
  - 2. Flexible, can be applied by hand.
  - 3. UL Listed for use with installed conductors.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS (NOT USED)**



## **2.07 ACCESSORIES (NOT USED)**

### **2.08 MIXES**

- A. Concrete mix requirements as specified in Section 03300 - Cast-In-Place Concrete.
- B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300 - Cast-In-Place Concrete.

### **2.09 FABRICATION (NOT USED)**

### **2.10 FINISHES (NOT USED)**

### **2.11 SOURCE QUALITY CONTROL (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Duct banks:
  - 1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
  - 2. Damage minimization:
    - a. Conduit should not be left exposed in an open trench longer than is necessary.
    - b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
  - 3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
  - 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
  - 5. Install underground ducts to be self-draining:
    - a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
    - b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
    - c. Slope a minimum of 1/4 inch per 10 feet.
  - 6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.



7. Install pull line in spare conduits:
  - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
  - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- C. Trenching:
  1. Perform trenching as specified in Section 02318 - Trenching.
  2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
  3. Whenever possible, use the walls of the trench as forms for concrete encasement:
    - a. Forms are required where the soil is not self-supporting.
  4. Avoid damaging existing ducts, conduits, cables, and other utilities.
- D. Duct spacing:
  1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
    - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
  2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
    - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
      - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
        - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
  3. Spacers shall not be located at the center of a bend:
    - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
    - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.
- E. Terminating:
  1. Use bell ends in duct at entrances into cable vaults.
  2. Make conduit entrances into cable vaults tangential to walls of cable vault.
  3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
  4. Install duct seal in all conduits including spare conduits, at entrance to manholes/handholes, and building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
  5. New manhole or handhole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.
- F. Concrete:
  1. Install concrete as specified in Section 03300 - Cast-In-Place Concrete.
  2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
    - a. Tie wire shall not act as a substitute for spacers.
  3. Install minimum 3-inch cover around conduit and rebar.



4. Consolidation of encasement concrete around duct banks shall be by hand puddling, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:

1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING**

- A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide shoring and pumping to protect the excavation and safety of workers.
- C. Protect excavations with barricades as required by applicable safety regulations.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 16134

### BOXES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Device boxes.
  - 2. Raceway system boxes.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. Standard Specifications for Highway Bridges.
- C. ASTM International (ASTM):
  - 1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
  - 2. D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
  - 3. D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
  - 4. D570 - Standard Test Method for Water Absorption of Plastics.
  - 5. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
  - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
  - 7. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
- D. Joint Industry Conference (JIC).
- E. Underwriters Laboratories, Inc. (UL):
  - 1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
  - 1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
  - 2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.



1.04

## **SYSTEM DESCRIPTION**

- A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.
- B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer.
  - 2. Materials.
  - 3. Dimensions:
    - a. Height.
    - b. Width.
    - c. Depth.
    - d. Weight.
    - e. NEMA rating.
  - 4. Conduit entry locations.
  - 5. Catalog cut sheets.
  - 6. Installation instructions.
- C. Shop drawings:
  - 1. Include identification and sizes of pullboxes.

### **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
  - 1. Outlet boxes shall comply with all applicable standards of:
    - a. JIC.
    - b. NEC.
    - c. NEMA.
    - d. UL.

### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **1.09 SEQUENCING**

- A. As specified in Section 16050 - Common Work Results for Electrical.



## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Cast device boxes:
    - a. Appleton.
    - b. Crouse - Hinds.
    - c. OZ/Gedney.
  - 2. Stainless steel enclosures:
    - a. Hoffman.
    - b. Stahlin.
    - c. Rittal.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS**

- A. Cast device boxes:
  - 1. Construction:
    - a. With internal green ground screw.
    - b. Furnished with a suitable gasketed cover.
    - c. With integral cast mounting lugs when surface mounted.
    - d. Conduit sizes range from 3/4 inch to 1 inch.
    - e. Tapered threaded hubs with integral bushing.
  - 2. Malleable iron boxes:
    - a. Conforming to ASTM A47 Grade 32510.
- B. Plastic coated cast device boxes:
  - 1. Construction:
    - a. With internal green ground screw.
    - b. Furnished with a suitable gasketed cover.
    - c. With integral cast mounting lugs when surface mounted.
    - d. Conduit sizes range from 3/4 inch to 1 inch.
    - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.



- f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
    - g. With pressure sealing sleeve to protect the connection with conduit.
- C. Class I Division 1 areas:
  - 1. Provide boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
    - a. The approval ratings must be permanently marked on each item.
- D. Class I, Division 2 areas:
  - 1. For boxes not containing arcing parts:
    - a. As specified in Section 16050 - Common Work Results for Electrical.
    - b. Pressed metal boxes are not allowed.
  - 2. For boxes containing arching parts provide:
    - a. Boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
      - 1) The approval ratings must be permanently marked on each item.
  - 3. Cast iron Cast copper - free aluminum box and cover.
  - 4. Precision machined flame path between box and cover with neoprene o-ring.
  - 5. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
  - 6. External flange.
  - 7. Provisions for mounting pan.
  - 8. Ground lug.
  - 9. Stainless steel:
    - a. NEMA Type 4X:
      - 1) Boxes in locations subject to flooding or temporary submersion:
        - a) NEMA Type 6.
    - b. Fabricated from 14-gauge Type 316 stainless steel.
    - c. All seams continuously welded.
    - d. Door:
      - 1) Rolled lip around 3 sides.
      - 2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
    - e. Neoprene door gasket to provide a watertight seal:
      - 1) Attached with an adhesive.
      - 2) Retained by a retaining strip.
    - f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
      - 1) With a hasp and staple for padlocking.
    - g. Provide large enclosures with door and body stiffeners for extra rigidity.
    - h. No holes or knockouts.
    - i. Finish:
      - 1) Brushed.
    - j. Stainless steel external mounting brackets when surface mounted.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS (NOT USED)**





## **2.07 ACCESSORIES**

- A. Fasteners:
  - 1. Electroplated or stainless steel in boxes with wiring devices.
  - 2. Screws, nuts, bolts, and other threaded fasteners:
    - a. Stainless steel.
- B. Provide breather and drain fittings where appropriate.
- C. Internal panels:
  - 1. Provide internal panels where required for mounting of terminal strips or other equipment.
  - 2. With plated steel shoulder studs.
  - 3. Steel with white polyester powder finish.

## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES (NOT USED)**

## **2.11 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
  - 1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.
  - 2. Provide outlet box materials to match the conduit system:
    - a. GRC - Cast ferrous boxes.
    - b. PCS - PVC coated cast ferrous boxes.
    - c. PVC - PVC boxes.
  - 3. Solid type gang boxes:
    - a. For more than 2 devices.
    - b. For barriered outlets.
  - 4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
    - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
    - b. Use stainless steel or nylon materials for spacers.
  - 5. Use cast malleable iron boxes when box must support other devices.



6. Boxes serving luminaires or devices:
    - a. Use as pullboxes wherever possible.
  7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
  8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
    - a. Furnish wireways for discrete and analog/DC wiring.
    - b. Separate analog wiring from 120 V discrete or power wiring.
  9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
  10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
- C. Outlet boxes:
1. Locate outlet boxes as indicated on the Drawings:
    - a. Adjust locations so as not to conflict with structural requirements or other trades.
  2. Use deep threaded-hub malleable iron or aluminum boxes:
    - a. In hazardous areas.
    - b. Where exposed to the weather.
    - c. In unheated areas.
    - d. Where subject to mechanical damage:
      - 1) Defined as exposed boxes less than 10 feet above the floor.
    - e. To act as a pullbox for conductors in a conduit system.
    - f. Accommodate wiring devices.
  3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
  4. Outlet boxes may be used as junction boxes wherever possible.
- D. Pullboxes and junction boxes:
1. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
  2. Install pullboxes such that access to them is not restricted.
- E. For boxes not indicated:
1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.
  2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
    - a. One-piece, galvanized, pressed steel.
  3. Ceiling boxes for flush mounting in concrete:
    - a. Deep, galvanized, pressed steel.
  4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
    - a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
  5. Outlet, control station, and junction boxes for installation in corrosive locations:
    - a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
    - b. Furnished with mounting lugs.



F. Hazardous locations:

1. All metallic boxes, fittings, and joints shall utilize threaded connections to the conduit system.
2. All threaded connections shall be wrench tightened so that at least 5 threads are fully engaged.
3. Conduits entering and exiting metallic boxes in Class I Division 2 areas shall utilize approved grounding bushings to bond the conduits together.
4. Provide the following types of conduit bodies and boxes:
  - a. Malleable iron bodies and boxes with GRC or IMC conduit systems.
  - b. PVC coated conduit bodies and boxes with PCS conduit systems.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 REINSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16150

### LOW VOLTAGE WIRE CONNECTIONS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Wire connecting devices.
  - 2. Terminations.
  - 3. Splices.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
  - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
  - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
  - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### 1.04 SYSTEM DESCRIPTION

- A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Catalog cut sheets.
  - 2. Installation instructions.

##### 1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All materials shall be UL listed.



## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Manufacturers for each type of technology are specified with the equipment in this Section.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**

## **2.05 EQUIPMENT**

- A. Control connections:
  - 1. Use insulated ring type wire terminators for connections to all screw terminals:
    - a. With chamfered/funneled terminal barrel entry.
    - b. Deep internal serrations.
    - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
    - d. Electroplated-tin copper conductor.
    - e. Manufacturers: The following or equal:
      - 1) Thomas and Betts, Stakon.
  - 2. For process equipment connections work from manufacturer's drawings.



B. Joints, splices, taps, and connections:

1. 600-volt conductors:
  - a. Use solderless connectors.
  - b. Use only plated copper alloy connectors or lugs:
    - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
  - c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
  - d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
    - 1) Manufacturers: The following or equal:
      - a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
  - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
    - 1) Manufacturers: One of the following or equal:
      - a) Burndy.
      - b) Thomas and Betts.
  - f. Heat shrink tubing:
    - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
    - 2) Minimum shrink ratio: 4 to 1.
    - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
    - 4) Internally applied adhesive sealant.
    - 5) Cross-linked polyolefin:
      - a) Manufacturers: One of the following or equal:
        - (1) 3M, ITCSN.
        - (2) Thomas & Betts, Shrink-Kon.
2. Instrumentation class cable splices:
  - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
  - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
  - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
  - d. Two-part mold body with tongue and groove seams and built in spacer webbing.
  - e. Manufacturers: The following or equal:
    - 1) 3M, Scotchcast 72-N.

C. Insulating tape:

1. General purpose insulating tape:
  - a. Minimum 7 mil vinyl tape.
  - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
  - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
  - d. Flame retardant, hot- and cold- weather resistant, UV resistant.
  - e. For use as a primary insulation for wire cable splices up to 600 VAC.
  - f. Meeting and complying with:
    - 1) ASTM D3005 Type I.
    - 2) UL 510.
    - 3) CSA C22.2.



- g. Manufacturers: The following or equal:
  - 1) 3M, Scotch Number Super 33+.
- 2. General-purpose color-coding tape:
  - a. Minimum 7 mil vinyl tape.
  - b. Suitable for application on PVC and polyethylene jacketed cables.
  - c. For use indoors and outdoors in weather protected enclosures.
  - d. Available with the following colors:
    - 1) Red.
    - 2) Yellow.
    - 3) Blue.
    - 4) Brown.
    - 5) Gray.
    - 6) White.
    - 7) Green.
    - 8) Orange.
    - 9) Violet.
  - e. For use as phase identification, marking, insulating, and harnessing.
  - f. Meeting and complying with:
    - 1) UL 510.
    - 2) CSA C22.2.
  - g. Manufacturers: The following or equal:
    - 1) 3M, Scotch Number 35.

#### **2.06 COMPONENTS (NOT USED)**

#### **2.07 ACCESSORIES (NOT USED)**

#### **2.08 MIXES (NOT USED)**

#### **2.09 FABRICATION (NOT USED)**

#### **2.10 FINISHES (NOT USED)**

#### **2.11 SOURCE QUALITY CONTROL (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Load connections:
  - 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.





- C. Zero to 600-volt systems:
  - 1. Make all connections with the proper tool and die as specified by the device manufacturer.
  - 2. Use only tooling and dies manufactured by the device manufacturer.
  - 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
  - 4. Number all power and control wires before termination.
- D. Motor connections (600 volts and below):
  - 1. Terminate all leads and wires with compression type ring lugs.
  - 2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
  - 3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
    - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
    - b. Shrink cap with low heat as recommended by manufacturer.
  - 4. Wire markers shall be readable after boot installation.
  - 5. Manufacturers: The following or equal:
    - a. Raychem, MCK.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

#### **3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **3.09 ADJUSTING (NOT USED)**

#### **3.10 CLEANING (NOT USED)**

#### **3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

#### **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16285

### SURGE PROTECTIVE DEVICES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. High-energy surge protective devices.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
  - 2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
  - 3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
  - 4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits.
- C. National Electrical Manufacturers Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. Underwriters Laboratory:
  - 1. 1449, 4th Edition, Standard for Surge Protective Devices.

##### 1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. NEMA:
  - 1. Type 1 enclosure in accordance with NEMA 250.
  - 2. Type 4 enclosure in accordance with NEMA 250.
  - 3. Type 4X enclosure in accordance with NEMA 250.
  - 4. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
  - 1. SPD: Surge protective device.
  - 2. SAD: Silicon avalanche diode.
  - 3. MOV: Metal oxide varistor.
  - 4. MCOV: Maximum continuous operating voltage.
  - 5.  $I_n$ : Nominal discharge current.
  - 6. VPR: Voltage protection rating.
  - 7. SCCR: Short circuit current rating.



## 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
  - 2. Manufacturer's catalog cut sheets indicating:
    - a. Manufacturer and model numbers.
    - b. Ratings of each SPD including but not limited to:
      - 1) Short circuit current rating.
      - 2) Nominal discharge current.
      - 3) Maximum continuous operating voltage.
      - 4) Voltage protection rating.
      - 5) System voltage.
      - 6) System frequency.
      - 7) Surge current capacity.
  - 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
    - a. Overcurrent protection.
    - b. UL 1449.
- C. Shop drawings:
  - 1. Provide electrical and mechanical drawings by the manufacturer that detail:
    - a. Unit dimensions.
    - b. Weights.
    - c. Components.
    - d. Field connection locations.
    - e. Mounting provisions.
    - f. Connection details.
    - g. Wiring diagram.
- D. Operation and maintenance manuals:
  - 1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

## 1.05 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
  - 1. Institute of Electrical and Electronics Engineers (IEEE C62.41.1, C62.41.2, C62.45, C62.62).
  - 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
  - 3. National Electrical Manufacturer Association.
  - 4. National Fire Protection Association (NFPA 20, 75 and 780).
  - 5. National Electric Code (NFPA 70).
  - 6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283).
  - 7. International Electrotechnical Commission (IEC 801).



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 SEQUENCING**

- A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

## **1.09 SCHEDULING (NOT USED)**

## **1.10 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Extended warranty:
  - 1. Furnish a manufacturer's full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
  - 2. Warranty shall include:
    - a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
    - b. A 24-hour toll-free 800-number for warranty support.

## **1.11 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.13 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Liebert.
  - 2. Eaton.
  - 3. Schneider Electric.
  - 4. General Electric.

## **2.02 SYSTEM DESCRIPTION**

- A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.



### 2.03 EXISTING PRODUCTS (NOT USED)

### 2.04 MATERIALS (NOT USED)

### 2.05 MANUFACTURED UNITS

- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.
- B. Electrical requirements:
1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
  2. MCOV:
    - a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
  3. Operating frequency:
    - a. 47 to 63 hertz.
  4. SCCR:
    - a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
    - b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
  5. Nominal discharge current  $I_n$ :
    - a. 20 kA.
  6. Maximum VPR:

Modes	<u>240/120</u>	<u>208Y/120</u>	480Y/277	480V
L-N, L-G, N-G	900	900	1,500	1,500
L-L	1,200	1,200	2000	2,000

7. Peak surge current:
    - a. Service entrance locations:
      - 1) 240 kA per phase minimum.
      - 2) 120 kA per mode minimum.
    - b. Branch locations:
      - 1) 120 kA per phase, minimum.
      - 2) 60 kA per mode minimum.
- C. Protection modes:
1. Provide SPD protection modes as follows:
    - a. Line to Neutral (L-N) where applicable.
    - b. Line to Ground (L-G).
    - c. Neutral to Ground (N-G), where applicable.
- D. Environmental requirements:
1. Storage temperature:
    - a. -40 degrees to 122 degrees Fahrenheit.
  2. Operating temperature:
    - a. 32 degrees to 140 Fahrenheit.
  3. Relative humidity:
    - a. 5 percent to 95 percent.



4. Audible noise:
  - a. Less than 45 dBa at 5 feet (1.5 m).
5. Operating altitude:
  - a. Zero to 12,000 feet above sea level.

- E. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B and C3 environments, as tested to IEEE C62.45.

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS**

- A. Enclosure:
  1. Located in electrical equipment as indicated on the Drawings.
  2. External mounting:
    - a. NEMA Type 4X enclosure:
      - 1) No ventilation openings.
    - b. Hinged cover requiring a tool for internal access.
    - c. Internal drawing pocket.
    - d. All monitoring indications must be visible without opening the door.
- B. Internal connections:
  1. Provide low impedance copper plates for intra-unit connections:
    - a. Attach surge modules using bolted connections to the plates for low impedance connections.
  2. Size all connections, conductors, and terminals for the specified surge current capacity.
- C. Surge diversion modules:
  1. MOV:
    - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent protection:
  1. Individually fuse all components, including suppression, filtering, and monitoring components:
    - a. Rated to allow maximum specified nominal discharge current capacity.
    - b. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections:
  1. Provide terminals to accommodate wire sizes up to #2 AWG.

## **2.08 ACCESSORIES**

- A. Unit status indicators:
  1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
    - a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
    - b. Indicates the status of protection on each mode or phase.



- B. Dry contacts for remote monitoring:
  - 1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.
- C. Provide an audible alarm which activates under any fault condition.
  - 1. Provide an alarm On/Off switch to silence the alarm.
  - 2. A visible LED will confirm whether alarm is On or Disabled.
  - 3. Locate both switches and the audible alarm on the unit's front cover.
- D. Provide an integral disconnect switch located in-line with the SPD enclosure:
  - 1. External manual operator.
  - 2. The switch shall disconnect all ungrounded circuit conductors from the SPD.
  - 3. The integral disconnect switch shall be capable of withstanding, without failure, the maximum published surge current magnitude and short circuit current without failure or damage to the switch.
- E. Interconnection cable:
  - 1. Interconnect the SPD to the power system using a manufacturer furnished assembly of low impedance coaxial cables installed in flexible conduit.
  - 2. Cable designed to transmit transients with minimal voltage drop.
  - 3. UL listed.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL**

- A. Permanently affix surge rating to the SPD.
- B. Perform manufacturer's standard factory test:
  - 1. Perform testing in accordance with UL 1449.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.
- C. Special techniques:
  - 1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
    - a. Twist the input conductors together to reduce input conductor inductance.





2. Interconnect the SPD to the power system using a manufacturer supplied interconnection cable consisting of low impedance coaxial cables installed in a flexible conduit.
3. Do not subject SPD to insulation resistance testing.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16950 - Field Electrical Acceptance Tests.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 16411

### DISCONNECT SWITCHES

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Fusible and non-fusible disconnect switches.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electric Manufacturer's Association (NEMA):
  - 1. 250 - Enclosures for Electrical Equipment.
  - 2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. Underwriters Laboratories Inc. (UL):
  - 1. 20 - General-Use Snap Switches.
  - 2. 98 - Enclosed and Dead-Front Switches.
  - 3. 508 - Standard for Industrial Control Equipment.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
  - 1. Safety switches and disconnect switches are to be considered synonymous.

##### **1.04 SYSTEM DESCRIPTION**

- A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.
- B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer.
  - 2. Manufacturer's specifications and description.
  - 3. Ratings:
    - a. Voltage.
    - b. Current.



- c. Horsepower.
    - d. Short circuit rating.
  - 4. Fused or non-fused.
  - 5. NEMA enclosure type.
  - 6. Dimensions:
    - a. Height.
    - b. Width.
    - c. Depth.
  - 7. Weight.
  - 8. Cross-referenced to the disconnect schedule indicated on the Drawings.
- C. Shop drawings:
  - 1. Manufacturer's installation instructions:
    - a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
    - b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
  - 2. Identify motor or equipment served by each switch; indicate nameplate inscription.
- D. Installation instructions:
  - 1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 - Common Work Results for Electrical and calculations:
    - a. Stamped by a professional engineer registered in the state where the Project is being constructed.

## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
  - 1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
  - 2. UL 98 - Enclosed and Dead-Front Switches.
- C. Disconnect switches shall be UL listed and labeled.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING**

- A. After successful review of the initial fault current study, submit complete equipment submittal.



## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Schneider Electric.
  - 2. Eaton.
  - 3. General Electric.
  - 4. Siemens.
  - 5. Appleton.
  - 6. Crouse-Hinds.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**

## **2.05 EQUIPMENT**

- A. Switch mechanism:
  - 1. Quick-make, quick-break heavy-duty operating mechanisms:
    - a. Provisions for padlocking the switch in the Off position.
    - b. A minimum of 90-degree handle travel position between Off and On positions:
      - 1) Provide handle position indicators to identify the handle position.
    - c. Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
      - 1) With an externally operated override.
- B. Switch interior:
  - 1. Switch blades visible when the switch is Off and the cover is open.
  - 2. Lugs:
    - a. Front accessible.
    - b. Removable.
    - c. UL listed for 60/75-degree Celsius copper conductors.
  - 3. Current carrying parts completely plated to resist corrosion.
  - 4. Removable arc suppressors to facilitate easy access to line side lugs.



5. Furnish equipment ground kits for every switch.
- C. Fused switches:
  1. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
    - a. Ratings 100 amperes through 600 amperes at 240 volts.
    - b. Ratings 30 amperes through 600 amperes at 600 volts.
    - c. Provide spring reinforced and plated fuse clips.
- D. Ratings:
  1. UL horsepower rated for AC or DC with the rating not less than the load served.
  2. Current:
    - a. 30 to 1,200 amperes.
  3. Voltage:
    - a. 250 volts AC, DC.
    - b. 600 volts (30 A to 200 A, 600 volts DC).
  4. Poles:
    - a. 2, 3, 4, and 6 poles.
  5. UL listed short circuit ratings:
    - a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
    - b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
    - c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
  6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.
- E. Size, fusing and number poles as indicated on the Drawings or as required:
  1. Provide solid neutral where indicated on the Drawings.

## **2.06 COMPONENTS (NOT USED)**

## **2.07 ACCESSORIES**

- A. Disconnect switches to have provisions for a field installable "B" type electrical interlock for position indication as indicated on the Drawings.
- B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.
- C. NEMA Type 7 and 9 enclosures furnished with drain and breather kit when used in outdoor applications.



**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL (NOT USED)**

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**

**3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
  - 1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
  - 2. Provide all mounting brackets, stands, supports and hardware as required:
    - a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
    - b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
  - 3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
    - a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
    - b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
  - 4. Provide a nameplate for each disconnect switch:
    - a. Provide per requirements specified in Section 16075 - Identification for Electrical Systems.
    - b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.



**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING (NOT USED)**

**3.10 CLEANING**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## **SECTION 16412**

### **LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Low voltage molded case circuit breakers.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electrical Manufacturers Association (NEMA):
  - 1. AB 3. - Molded Case Circuit Breakers and Their Application.
- C. Underwriter's Laboratories (UL):
  - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
  - 2. 943 - Ground Fault Circuit Interrupters.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. In accordance with UL 489.

##### **1.04 SYSTEM DESCRIPTION**

- A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Catalog cut sheets.
  - 2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

##### **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Low voltage molded case circuit breakers shall be UL listed and labeled.



**1.07 DELIVERY, STORAGE AND HANDLING**

A. As specified in Section 16050 - Common Work Results for Electrical.

**1.08 PROJECT OR SITE CONDITIONS**

A. As specified in Section 16050 - Common Work Results for Electrical.

**1.09 SEQUENCING (NOT USED)**

**1.10 SCHEDULING (NOT USED)**

**1.11 WARRANTY**

A. As specified in Section 16050 - Common Work Results for Electrical.

**1.12 SYSTEM START-UP**

A. As specified in Section 16050 - Common Work Results for Electrical.

**1.13 OWNER'S INSTRUCTIONS (NOT USED)**

**1.14 MAINTENANCE (NOT USED)**

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A. One of the following or equal:
1. Eaton.
  2. General Electric Co.
  3. Schneider Electric.
  4. ABB.

**2.02 EXISTING PRODUCTS (NOT USED)**

**2.03 MATERIALS (NOT USED)**

**2.04 MANUFACTURED UNITS**

- A. General:
1. Conforming to UL 489.
  2. Operating mechanism:
    - a. Quick-make, quick-break, non-welding silver alloy contacts.
    - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
    - c. Mechanically trip free from the handle.
    - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
    - e. Lockable in the "OFF" position.



3. Arc extinction:
  - a. In arc chutes.
4. Voltage and current ratings:
  - a. Minimum ratings as indicated on the Drawings.
  - b. Minimum frame size 100A.
5. Interrupting ratings:
  - a. Minimum ratings as indicated on the Drawings.
  - b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:

1. Instantaneous only circuit breaker as part of a listed combination motor controller.
2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

## **2.05 EQUIPMENT (NOT USED)**

## **2.06 COMPONENTS**

A. Terminals:

1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.

B. Case:

1. Molded polyester glass reinforced.
2. Ratings clearly marked.

C. Trip units:

1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
2. Thermal magnetic:
  - a. Instantaneous short circuit protection.
  - b. Inverse time delay overload.
  - c. Ambient or enclosure compensated by means of a bimetallic element.
3. Solid state:
  - a. With the following settings as indicated on the Drawings.
    - 1) Adjustable long time current setting.
    - 2) Adjustable long time delay.
    - 3) Adjustable short time pickup.
    - 4) Adjustable short time delay.
    - 5) Adjustable instantaneous pickup.
    - 6) Adjustable ground fault pickup as indicated on the Drawings.
    - 7) Adjustable ground fault delay as indicated on the Drawings.

D. Molded case circuit breakers for use in panelboards:

1. Bolt-on type:
  - a. Plug-in type breakers are not acceptable.
2. Ground fault trip devices as indicated on the Drawings.



**2.07 ACCESSORIES (NOT USED)**

**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL**

- A. Test breakers in accordance with:
  - 1. UL 489.
  - 2. Manufacturer's standard testing procedures.

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**

**3.03 INSTALLATION**

- A. Install breakers to correspond to the accepted shop drawings.

**3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

**3.05 REPAIR/RESTORATION (NOT USED)**

**3.06 RE-INSTALLATION (NOT USED)**

**3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.

**3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

**3.09 ADJUSTING**

- A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.
- B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.



**3.10 CLEANING (NOT USED)**

**3.11 PROTECTION**

A. As specified in Section 16050 - Common Work Results for Electrical.

**3.12 SCHEDULES (NOT USED)**

END OF SECTION





## **SECTION 16445**

### **PANELBOARDS**

#### **PART 1 GENERAL**

##### **1.01 SUMMARY**

- A. Section includes:
  - 1. Panelboards serving feeder circuits and branch circuits.

##### **1.02 REFERENCES**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Underwriter's Laboratories, Inc. (UL):
  - 1. 67 - Standard for Panelboards.

##### **1.03 DEFINITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

##### **1.04 SYSTEM DESCRIPTION**

- A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
  - 1. Service voltage and configuration as indicated on the panel schedules.

##### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
  - 1. Manufacturer of panelboard.
  - 2. Bill of material.
  - 3. Assembly ratings including:
    - a. Voltage.
    - b. Phase.
    - c. Continuous current.
    - d. Short circuit interrupting rating.
  - 4. NEMA enclosure type.
  - 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
  - 6. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
  - 7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
    - a. Manufacturer's statement of seismic qualification with substantiating test data.



- b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
  - 1. Drawings to contain:
    - a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
      - 1) Height.
      - 2) Length.
      - 3) Width.
    - b. Weight.
    - c. Anchoring locations.
    - d. Breaker layout drawing with dimensions:
      - 1) Location of the main, branches, solid neutral, and ground.
    - e. Conduit entry/exit locations:
      - 1) Identify all conduit entry/exit locations and restrictions.
    - f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Installation instructions:
  - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
  - 2. For equipment installed in structures designated as seismic design category A or B:
    - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
  - 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
    - b. Submit anchoring drawings with supporting calculations.
    - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operations and maintenance manual:
  - 1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
    - a. Including but not limited to:
      - 1) Instruction narratives and bulletins.
      - 2) Renewal parts lists.
      - 3) Time-current curves for all devices.
- F. Calculations:
  - 1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.





## **1.06 QUALITY ASSURANCE**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Panelboards shall be UL listed and labeled.
  - 1. Where indicated as service entrance equipment, panelboards shall be UL labeled and listed "Suitable for Service Entrance."

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Eaton.
  - 2. General Electric Co.
  - 3. Schneider Electric.
- B. Circuit breakers:
  - 1. Same manufacturer as the panelboard.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS (NOT USED)**



2.05

## EQUIPMENT

- A. Provide panelboards with:
  - 1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
  - 2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.
- B. Short circuit rating:
  - 1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
  - 2. Testing method in accordance with UL 67.
  - 3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
  - 4. Panelboards shall be fully rated.

## 2.06 COMPONENTS

- A. Enclosure:
  - 1. NEMA enclosure type as indicated on the Drawings.
    - a. Where not indicated on the Drawings, as specified in Section 16050 - Common Work Results for Electrical for the installed location.
  - 2. Minimum width: 20 inches.
  - 3. Gutter space in accordance with the NEC:
    - a. Minimum of 4 inches of gutter space.
  - 4. Dead-front, no live parts when the panelboard is in service.
  - 5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
  - 6. 4-piece front to provide ease of wiring access.
  - 7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
    - a. Minimum 2 keys per panelboard.
    - b. Key all panelboard locks alike.
  - 8. Circuit directory frame and card on the inside of the door.
  - 9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
  - 10. Outdoor locations: Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.
- B. Bus:
  - 1. General:
    - a. Tin-plated copper.
  - 2. Phase bus:
    - a. Full size and height without reduction.
    - b. Dimensions and temperature rise in accordance with UL 67:
      - 1) Limit current density to less than 1,000 amps per square inch.
    - c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
  - 3. Ground bus:
    - a. Copper, solidly bonded.



4. Neutral bus:
  - a. Provide where indicated on the Drawings.
  - b. 100 percent rated.
  - c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

- C. Lugs:
  1. UL listed for copper and aluminum wire:
    - a. Provide lugs rated for 75-degree Celsius terminations.
    - b. Provide bolted or compression main lug terminations as required for the incoming cable size.
- D. Circuit breakers: As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
  1. Provide all circuit breakers with bolt-on connections:
    - a. Plug-in circuit breakers are not allowed.

## **2.07 ACCESSORIES**

- A. Surge protective devices:
  1. Furnish panelboards with surge protective devices as indicated on the Drawings.
  2. As specified in Section 16285 - Surge Protective Devices.
- B. Nameplates:
  1. As specified in Section 16075 - Identification for Electrical Systems.
  2. Install on outside of door.
  3. Indicating:
    - a. Panel designation.
    - b. Voltage.
    - c. Number of phases and configuration.
- C. Circuit identification labels:
  1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
  2. Type all information on the cards using designations in the panel schedules.
  3. Laminated on both sides.
- D. Pad locking mechanism:
  1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
  2. At a minimum, provide 1 mechanism per panelboard:
    - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.



## **2.08 MIXES (NOT USED)**

## **2.09 FABRICATION (NOT USED)**

## **2.10 FINISHES**

- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.
- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

## **2.11 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
  - 1. Surface, flush or MCC mounted as indicated on the Drawings.
  - 2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
  - 3. Perform work in accordance with the manufacturer's instructions and shop drawings.
  - 4. Provide all brackets, hangers, supports, and hardware for mounting as required.
  - 5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
    - a. Use only stainless steel mounting hardware.
  - 6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

## **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

## **3.05 REPAIR/RESTORATION (NOT USED)**

## **3.06 RE-INSTALLATION (NOT USED)**



### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Factory testing:
  - 1. Perform standard factory tests on the panelboards:
  - 2. Test in accordance with the latest version of NEMA and UL standards.

### **3.08 FIELD QUALITY CONTROL**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.09 ADJUSTING (NOT USED)**

### **3.10 CLEANING**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.12 SCHEDULES**

- A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.
- B. Provide typewritten schedule in each panelboard.

END OF SECTION





## SECTION 16950

### FIELD ELECTRICAL ACCEPTANCE TESTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Responsibilities for testing the electrical installation.
  - 2. Adjusting and calibration.
  - 3. Acceptance tests.
- B. Copyright information:
  - 1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

##### 1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American National Standards Institute (ANSI).
- C. ASTM International (ASTM):
  - 1. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
  - 2. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
  - 3. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
  - 4. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
  - 5. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
  - 6. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
  - 7. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
  - 8. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
  - 9. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
  - 10. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
  - 11. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
- D. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
  - 2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.



3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
  4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
  5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
  6. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
  7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
  8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
  9. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
  10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
  11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
- E. Insulated Cable Engineer's Association (ICEA).
- F. InterNational Electrical Testing Association (NETA).
1. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- G. International Electrotechnical Commission (IEC).
- H. Manufacturer's testing recommendations and instruction manuals.
- I. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
  2. 110 - Standard for Emergency and Standby Power Systems.
- J. National Institute of Standards and Technology (NIST).
- K. Specification sections for the electrical equipment being tested.
- L. Shop drawings.

### **1.03 DEFINITIONS**

- A. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.
- B. Specific definitions:
1. Testing laboratory: The organization performing acceptance tests.

### **1.04 SYSTEM DESCRIPTION**

- A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.





- B. Conduct all tests in the presence of the Engineer or the Engineer's representative.
  - 1. Engineer will witness all visual, mechanical, and electrical tests, and inspections.
- C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.
- D. Responsibilities:
  - 1. Contractor responsibilities:
    - a. Ensure that all resources are made available for testing, and that all testing requirements are met.
  - 2. Electrical subcontractor responsibilities:
    - a. Perform routine tests during installation.
    - b. Demonstrate operation of electrical equipment.
    - c. Commission the electrical installation.
    - d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
      - 1) Providing electrical power as required.
      - 2) Operating of electrical equipment in conjunction with testing of other equipment.
      - 3) Activating and shutting down electrical circuits.
      - 4) Making and recording electrical measurements.
      - 5) Replacing blown fuses.
      - 6) Installing temporary jumpers.
  - 3. Testing laboratory responsibilities:
    - a. Perform all acceptance tests specified in this Section.
    - b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

#### **1.05 SUBMITTALS**

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. LAN cable test form:
  - 1. LAN cable test reports:
    - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
      - 1) Test type.
      - 2) Test location.
      - 3) Test date.
      - 4) Cable number.
      - 5) Cable length.
      - 6) Certification that the cable meets or exceeds the specified standard.
    - b. Furnish hard copy and electronic copy for all traces.
- C. Manufacturers' testing procedures:
  - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.



D. Test report:

1. Include the following:
  - a. Summary of Project.
  - b. Description of equipment tested.
  - c. Description of tests performed.
  - d. Test results.
  - e. Conclusions and recommendations.
  - f. Completed test forms.
  - g. List of test equipment used and calibration dates.
  - h. LAN cable test reports.

E. Test data records:

1. Include the following:
  - a. Identification of the testing organization.
  - b. Equipment identification.
  - c. Nameplate data.
  - d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
  - e. Dates of inspections, tests, maintenance and or calibrations.
  - f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
  - g. Expected results when calibrations are to be performed.
  - h. Indication of as-found and as-left results as applicable.
  - i. Indication of all test results outside specified tolerances.

F. Testing laboratory qualifications:

1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
  - a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
    - 1) Corporate history and references.
    - 2) Resume of individual performing test.
    - 3) Equipment list and test calibration data.

G. Division of responsibilities:

1. Submit a list identifying who is responsible for performing each portion of the testing.

## 1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Testing laboratory qualifications:

1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

## 1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)



## **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.09 SEQUENCING**

- A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.
- B. Perform testing in the following sequence:
  - 1. Perform routine tests as the equipment is installed including:
    - a. Insulation-resistance tests.
    - b. Continuity tests.
    - c. Rotational tests.
  - 2. Adjusting and preliminary calibration.
  - 3. Acceptance tests.
  - 4. Demonstration.
  - 5. Commissioning and plant start-up.

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 16050 - Common Work Results for Electrical.

## **1.12 SYSTEM START-UP (NOT USED)**

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION**

- A. Test instrument calibration:
  - 1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
    - a. The calibrating standard shall be of better accuracy than that of the equipment tested.
  - 2. The accuracy shall be traceable to the NIST in an unbroken chain.
  - 3. Calibrate instruments in accordance with the following frequency schedule:
    - a. Field instruments: 6 months maximum.
    - b. Laboratory instruments: 12 months maximum.



- c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
  - 4. Dated calibration labels shall be visible on all test equipment.
  - 5. Maintain an up-to-date instrument calibration record for each test instrument:
    - a. The records shall show the date and results of each calibration or test.
  - 6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
- B. Do not begin testing until the following conditions have been met:
  - 1. All instruments required are available and in proper operating condition.
  - 2. All required dispensable materials such as solvents, rags, and brushes are available.
  - 3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
  - 4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
  - 5. Data sheets to record all test results are available.

### **3.03 INSTALLATION**

- A. Test decal:
  - 1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
  - 2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
    - a. White: electrically and mechanically acceptable.
    - b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
  - 3. The decal shall include the following information at a minimum:
    - a. Testing organization.
    - b. Project identifier.
    - c. Test date.
    - d. Technician identifier.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Testing and Training Phase: Installation Testing:
  - 1. Also called "Field Acceptance Testing".
  - 2. Panelboards:
    - a. Cleaning:
      - 1) Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.



- 2) Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
  - 3) Avoid blowing dust into panelboards. Do not use a blower or compressed air.
  - 4) Clean Supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
  - 5) Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
- b. General:
- 1) Compare equipment nameplate data with the Contract Documents.
  - 2) Check panelboard circuit schedule for accuracy.
  - 3) Verify appropriate anchorage, required area clearances, and correct alignment.
  - 4) Inspect overall general condition for physical damage. Check for broken studs and loose or damaged wires, connector, terminations, etc. Check all bolts, nuts, washer, and pins for tightness. Tighten or use manufacture's replacement parts as required.
  - 5) Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
  - 6) Check that covers are in place and fastened. Plug any open unused knockouts.
  - 7) Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect all component devices. Replace any components that show evidence of damage from moisture.
  - 8) Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
  - 9) Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking. Investigate and correct sources of arcing or overheating. Consult the panelboard manufacturer for recommendations.
  - 10) Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breaker's address for microprocessor communications packages, if equipped.
  - 11) Set adjustable circuit breakers in accordance with engineering coordination study supplied by **Owner**.
- c. Terminations, Connections, and Lugs:
- 1) Inspect bolted electrical connections for high resistance using one of the following methods:
    - a) Use of low-resistance ohmmeter.
      - (1) Compare bolted connection resistance values to values of similar connections:
        - (a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.



- b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
  - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
  - 2) Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
  - 3) Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
  - 4) Replace overheated connections. Tighten connections to proper to proper torque levels as specified above.
- d. Conductors and raceways:
  - 1) Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
  - 2) Ensure the conductors are protected within their ampacities.
  - 3) Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
  - 4) Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with manufacturer's recommendations.
  - 5) Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
  - 6) Inspect for frayed or broken wires. Replace or repair conductors as necessary.
  - 7) Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.
- e. Circuit breakers:
  - 1) Breakers rated less than 100 A:
    - a) Operate circuit breakers several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
    - b) Visually check circuit breakers for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
    - c) Check circuit breakers for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
    - d) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
    - e) Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
    - f) Check circuit breaker terminals and connections for tightness as specified above.
  - 2) Breakers rated 100 A and higher:
    - a) Perform visual and mechanical inspection as specified in this Section.
    - b) Perform electrical tests as specified in this Section.



3. Dry type transformers:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Verify that resilient mounts are free and that any shipping brackets have been removed.
    - 5) Inspect equipment for cleanliness.
    - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 7) Verify that as-left tap connections are as specified.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
      - a) Apply voltage in accordance with manufacturer's published data.
        - (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Calculate dielectric absorption ration or polarization index.
    - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
  - c. Test values:
    - 1) Compare bolted connection resistance values to values of similar connections:
      - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Tap connections are left as found unless otherwise specified.
    - 4) Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
      - b) Investigate insulation values less than the allowable minimum.
    - 5) The dielectric absorption ratio or polarization index shall not be less than 1.0.
    - 6) Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
    - 7) Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.
4. Low voltage cables, 600 volt maximum:
  - a. Visual and mechanical inspection:
    - 1) Compare cable data with the Drawings and Specifications.





- 2) Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
- 3) Inspect bolted electrical connections for high resistance by one of the following methods:
  - a) Use of low-resistance ohmmeter.
  - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
    - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- 4) Inspect compression applied connectors for correct cable match and indentation.
- 5) Inspect for correct identification and arrangement.
- 6) Inspect cable jacket insulation and condition.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
    - a) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
    - b) Test duration shall be 1 minute.
  - 3) Perform continuity tests to insure correct cable connection.
  - 4) Verify uniform resistance of parallel conductors.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate values of insulation-resistance less than the allowable minimum.
  - 3) Cable shall exhibit continuity.
  - 4) Deviations in resistance between parallel conductors shall be investigated.
5. Low voltage molded case and insulated case circuit breakers:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage and alignment.
    - 4) Verify the unit is clean.
    - 5) Operate the circuit breaker to ensure smooth operation.
    - 6) Inspect bolted electrical connections for high resistance by one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.





- 7) Perform adjustments for final protective device settings in accordance with the coordination study.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
    - a) Apply voltage in accordance with manufacturer's published data.
    - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Perform a contact/pole-resistance test.
  - 4) Determine long-time pickup and delay by primary current injection.
  - 5) Determine short-time pickup and delay by primary current injection.
  - 6) Determine ground-fault pickup and delay by primary current injection.
  - 7) Determine instantaneous pickup value by primary current injection.
  - 8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
  - 9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
    - a) Reset all trip logs and indicators.
  - 10) Verify operation of charging mechanism.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate values of insulation-resistance less than the allowable minimum.
  - 4) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
    - a) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
  - 5) Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
    - a) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
  - 6) Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.



- 7) Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
  - 8) Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 9) Pickup values and trip characteristics shall be within manufacturer's published tolerances.
  - 10) Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
  - 11) The charging mechanism shall operate in accordance with manufacturer's published data.
6. Instrument transformers - current transformers:
- a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Verify correct connection of transformers with system requirements.
    - 4) Verify that adequate clearances exist between primary and secondary circuit wiring.
    - 5) Verify the unit is clean.
    - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 7) Verify that all required grounding and shorting connections provide contact.
    - 8) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
      - a) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
    - 3) Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
    - 4) Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
    - 5) Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
    - 6) Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
    - 7) When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:
      - a) Test voltages shall be in accordance with NETA ATS tables.
    - 8) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.



- 9) Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
  - a) That grounding point should be located as specified by the Engineer in the Contract Documents.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 4) Polarity results shall agree with transformer markings.
  - 5) Ratio errors shall be in accordance with IEEE C57.13.
  - 6) Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
  - 7) Measured burdens shall be compared to instrument transformer ratings.
  - 8) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
  - 9) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
    - a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.
  - 10) Test results shall indicate that the circuits have only 1 grounding point.
7. Instrument transformers - voltage transformers:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Verify correct connection of transformers with system requirements.
    - 4) Verify that adequate clearances exist between primary and secondary circuit wiring.
    - 5) Verify the unit is clean.
    - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 7) Verify that all required grounding and connections provide contact.
    - 8) Verify correct primary and secondary fuse sizes for voltage transformers.



- 9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- 10) Perform as-left tests.
- b. Electrical tests - voltage transformers:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation-resistance tests winding-to-winding and winding-to-ground:
    - a) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
    - b) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
  - 3) Perform a polarity test on each voltage transformer to verify the polarity marks on H<sub>1</sub>- X<sub>1</sub> relationship as applicable.
  - 4) Perform a turns ratio test on all tap positions.
  - 5) Measure voltage circuit burdens at transformer terminals.
  - 6) Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
    - a) The dielectric voltage shall be in accordance with NETA ATS tables.
    - b) Apply the test voltage for 1 minute.
  - 7) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
  - 8) Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
    - a) That grounding point should be located as specified by the Engineer in the Contract Documents.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 4) Polarity results shall agree with transformer markings.
  - 5) Ratio errors shall be in accordance with IEEE C57.13.
  - 6) Measured burdens shall be compared to instrument transformer ratings.
  - 7) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
  - 8) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
    - a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.



- 9) Test results shall indicate that the circuits have only 1 grounding point.
8. Metering devices, microprocessor based:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect meters and cases for physical damage.
    - 3) Clean front panel.
    - 4) Verify tightness of electrical connections.
    - 5) Record the following:
      - a) Model number.
      - b) Serial number.
      - c) Firmware revision.
      - d) Software revision.
      - e) Rated control voltage.
    - 6) Verify operation of display and indicating devices.
    - 7) Record passwords.
    - 8) Verify the unit is grounded in accordance with the manufacturer's instructions.
    - 9) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
  - b. Electrical tests:
    - 1) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
    - 2) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital and analog.
    - 3) After initial system energization, confirm measurements and indications are consistent with loads present.
  - c. Test values:
    - 1) Nameplate data shall match the Contract Documents.
    - 2) Tightness of electrical connections shall ensure a low resistance connection.
    - 3) Display and indicating devices shall operate per manufacturer's published data.
    - 4) Measurement and indication of applied voltages and currents shall be within the manufacturer's published tolerances for accuracy.
    - 5) All auxiliary input/output features shall operate per settings and manufacturer's published data.
    - 6) Measure and indications shall be consistent with energized system loads.
9. Grounding systems:
  - a. Visual and mechanical inspection:
    - 1) Inspect ground system for compliance with the Contract Documents, and the NEC.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.



- 4) Inspect anchorage.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
    - 3) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
  - c. Test values:
    - 1) Grounding system electrical and mechanical connections shall be free of corrosion.
    - 2) Compare bolted connection resistance values to values of similar connections:
      - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 3) Bolt-torque levels shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 4) The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding.
    - 5) Investigate point-to-point resistance values that exceed 0.5 ohm.
10. Rotating machinery, ac induction motors and generators:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate information with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging
    - 5) Inspect bolted electrical connections for high resistance using one or more of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 6) Verify correct application of appropriate lubrication and lubrication systems.
    - 7) Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
  - b. Electrical tests - AC Induction:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform insulation-resistance test in accordance with IEEE 43:
      - a) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30 second periods.
      - b) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.





- 3) On machines rated at 2,300 volts and greater, perform dielectric withstand voltage tests in accordance with:
  - a) IEEE 95 for dc dielectric withstand voltage tests.
  - b) NEMA MG1 for ac dielectric withstand voltage tests.
- 4) Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
- 5) Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.
- 6) Test surge protection devices as specified in this Section.
- 7) Test motor starter as specified in this Section.
- 8) Perform resistance tests on resistance temperature detector (RTD) circuits.
- 9) Verify operation of motor space heater, if applicable.
- c. Test values:
  - 1) Inspection:
    - a) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
    - b) Filter media shall be clean and installed in accordance with the manufacturer's published data.
    - c) Cooling fans shall operate.
    - d) Slip ring alignment shall be within manufacturer's published tolerances.
    - e) Brush alignment shall be within manufacturer's published tolerances.
    - f) Brush rigging shall be within manufacturer's published tolerances.
  - 2) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 3) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 4) Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
  - 5) The recommended minimum insulation-resistance ( $IR_{1 \min}$ ) test results in megohms shall be in accordance with NETA ATS tables.
    - a) The polarization index value shall not be less than 2.0.
    - b) The dielectric absorption ratio shall not be less than 1.4.
  - 6) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
  - 7) Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.
  - 8) Power factor or dissipation factor values shall be compared to manufacturer's published data:
    - a) In the absence of manufacturer's published data, compare values of similar machines.
  - 9) Tip-up values shall indicate no significant increase in power factor.



- 10) If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
  - 11) Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
    - a) In the absence of manufacturer's published data, compare values of similar machines.
  - 12) Test results of surge protection devices shall be as specified in this Section.
  - 13) Test results of motor starter equipment shall be as specified in this Section.
  - 14) RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
  - 15) Heaters shall be operational.
  - 16) Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with manufacturer's published data:
    - a) In the absence of manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
    - b) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
11. Motor starters, low voltage:
- a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate information with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Verify the unit is clean.
    - 5) Inspect contactors:
      - a) Verify mechanical operation.
      - b) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer's published data.
    - 6) Motor-running protection:
      - a) Verify overload element rating/motor protection settings are correct for its application.
      - b) If motor running protection is provided by fuses, verify correct fuse rating.
    - 7) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 8) Lubrication requirements:
      - a) Verify appropriate lubrication on moving current-carrying parts.
      - b) Verify appropriate lubrication on moving and sliding surfaces.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.





- 2) Perform insulation-resistance tests for 1 minute on each pole, phase to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
  - a) Test voltage shall be in accordance with manufacturer's published data.
  - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
- 3) Test motor protection devices in accordance with manufacturer's published data.
- 4) Test circuit breakers as specified in this Section.
- 5) Perform operational tests by initiating control devices.
- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate values of insulation-resistance less than the allowable minimum.
  - 4) Motor protection parameters shall be in accordance with manufacturer's published data.
  - 5) Circuit breaker test results shall as specified in this Section.
  - 6) Control devices shall perform in accordance with system design requirements.
12. Motor control centers, low voltage:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, grounding and required clearances.
    - 4) Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
    - 5) Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
    - 6) Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
    - 7) Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
    - 8) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.



- 9) Verify operation and sequencing of interlocking systems:
  - a) Attempt closure on locked-open devices.
  - b) Attempt to open locked-closed devices.
  - c) Make/attempt key-exchanges in all positions.
- 10) Lubrication requirements:
  - a) Verify appropriate lubrication on moving current-carrying parts.
  - b) Verify appropriate lubrication on moving and sliding surfaces.
- 11) Inspect insulators for evidence of physical damage or contaminated surfaces.
- 12) Verify correct barrier and shutter installation and operation.
- 13) Exercise all active components.
- 14) Inspect all indicating devices for correct operation.
- 15) Verify that filters are in place and/or vents are clear.
- 16) Perform visual and mechanical inspection of instrument transformers as specified in this Section.
- 17) Perform visual and mechanical inspection of surge arresters as specified in this Section.
- 18) Inspect control power transformers:
  - a) Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.
  - b) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
  - c) Verify correction functioning of grounding contacts.
- 19) Perform visual and mechanical inspection of all motor control center components as specified in this Section.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
  - 2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
    - a) Perform test in accordance with NETA ATS tables.
  - 3) Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
  - 4) Perform ground-resistance tests:
    - a) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
  - 5) Control power transformers:
    - a) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
      - (1) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
    - b) Perform secondary wiring integrity test:
      - (1) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
        - (a) Verify correct potential at all devices.



- c) Verify correct secondary voltage by energizing primary winding with system voltage:
        - (1) Measure secondary voltage with the secondary wiring disconnected.
    - 6) Verify operation of space heaters.
    - 7) Perform electrical tests of all motor control center components as specified in this Section.
  - c. Test values:
    - 1) Compare bolted connection resistance values to values of similar connections:
      - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:
      - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
      - b) Investigate insulation values less than the allowable minimum.
      - c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
    - 4) Bus insulation shall withstand the over potential test voltage applied.
    - 5) Instrument transformer test values shall be as specified in this Section.
    - 6) Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
    - 7) Meter accuracy shall be in accordance with manufacturer's published data.
    - 8) Control power transformers:
      - a) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:
        - (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        - (2) Investigate insulation values less than the allowable minimum.
        - (3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
      - b) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
      - c) Secondary voltage shall be as indicated on the Drawings.
    - 9) Heaters shall be operational.
    - 10) Test values for motor control center components shall be as specified in this Section.
13. Variable frequency drive systems:
- a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, and grounding.
    - 4) Verify the unit is clean.



- 5) Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
- 6) Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
- 7) Motor running protection:
  - a) Verify drive overcurrent setpoints are correct for their application.
  - b) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
  - c) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
- 8) Inspect bolted electrical connections for high resistance using one of the following methods:
  - a) Use of low-resistance ohmmeter.
  - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
    - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- 9) Verify correct fuse sizing in accordance with manufacturer's published data.
- 10) Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
- b. Electrical tests:
  - 1) Perform resistance measurements through bolted connections with low resistance ohmmeter.
  - 2) Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
  - 3) Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS or as recommended by the manufacturer:
    - a) Input phase loss protection.
    - b) Input overvoltage protection.
    - c) Output phase rotation.
    - d) Overtemperature protection.
    - e) Direct current overvoltage protection.
    - f) Overfrequency protection.
    - g) Drive overload protection.
    - h) Fault alarm outputs.
  - 4) Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
  - 5) Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
  - 6) Perform operational tests by initiating control devices:
    - a) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
    - b) Verify operation of drive from remote start/stop and speed control signals.
  - 7) Perform electrical tests of input circuit breaker as specified in this Section.
  - 8) Measure fuse resistance.



- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
  - 4) Test values for input circuit breaker shall be as specified in this Section.
  - 5) Relay calibration results shall be as specified in this Section.
  - 6) Continuity of bonding conductors shall be in accordance with NETA ATS.
  - 7) Control devices shall perform in accordance with system requirements.
  - 8) Operational tests shall conform to system design requirements.
  - 9) Investigate fuse resistance values that deviate from each other by more than 15 percent.
- 14. Surge arresters, low-voltage:
  - a. Visual and mechanical inspection:
    - 1) Compare equipment nameplate data with the Contract Documents.
    - 2) Inspect physical and mechanical condition.
    - 3) Inspect anchorage, alignment, grounding, and clearances.
    - 4) Verify the arresters are clean.
    - 5) Inspect bolted electrical connections for high resistance using one of the following methods:
      - a) Use of low-resistance ohmmeter.
      - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
    - 6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
    - 7) Verify that stroke counter is correctly mounted and electrically connected, if applicable.
    - 8) Record stroke counter reading.
  - b. Electrical tests:
    - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    - 2) Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
      - a) Apply voltage in accordance with manufacturers published data.
      - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - 3) Test grounding connection as specified in this Section.



- c. Test values:
  - 1) Compare bolted connection resistance values to values of similar connections:
    - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
  - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
    - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    - b) Investigate insulation values less than the allowable minimum.
  - 4) Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
- 15. Fiber-optic cables:
  - a. Visual and mechanical inspection:
    - 1) Compare cable, connector, and splice data with the Contract Documents.
    - 2) Inspect cable and connections for physical and mechanical damage.
    - 3) Verify that all connectors and splices are correctly installed.
  - b. Optical tests:
    - 1) Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
      - a) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
      - b) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
    - 2) Perform connector and splice integrity test using an optical time domain reflectometer.
    - 3) Perform cable attenuation loss measurement with an optical power loss test set:
      - a) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
      - b) Test multimode fibers at 850 nanometer and 1,300 nanometer.
      - c) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
    - 4) Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
      - a) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
    - 5) Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
      - a) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.



- b) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
- c. Test values:
  - 1) Cable and connections shall not have been subjected to physical or mechanical damage.
  - 2) Connectors and splices shall be installed in accordance with industry standards.
  - 3) The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
  - 4) Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
  - 5) Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

### **3.08 FIELD QUALITY CONTROL (NOT USED)**

### **3.09 ADJUSTING (NOT USED)**

### **3.10 CLEANING**

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

### **3.11 PROTECTION**

- A. As specified in Section 16050 - Common Work Results for Electrical.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17050

### COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. General requirements applicable to all Process Control and Instrumentation Work.
  - 2. General requirements for process control and instrumentation submittals.
  - 3. As specified in this Section, some SCADA/HMI software configuration will be provided by the Owner. **SPECIFICALLY, THE HMI CONFIGURATION WILL BE BY OWNER, ALL OTHER PROGRAMMING AND INTEGRATION SHALL BE BY CONTRACTOR.**
- B. Interfaces to equipment, instruments, and other components:
  - 1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
  - 2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
    - a. Make all changes necessary to meet the manufacturer's wiring requirements.
  - 3. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation, control systems, and related services are provided. Include any items indicated on the Drawings or in Specifications from other disciplines in the scope of Work.
  - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
    - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
  - 5. Loop drawings:
    - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
    - b. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.



- C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
  2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
- D. Contract Documents:
1. General:
    - a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
  2. Specifications:
    - a. Documents 00700 - General Conditions and 00712 - Supplementary Conditions of the Contract Documents govern the Work.
    - b. These requirements are in addition to all General Requirements.
  3. Contract drawings:
    - a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
    - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
      - 1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
      - 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
  - c. Installation details:
    - 1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
  - d. Schematic diagrams:
    - 1) All controls are shown de-energized.



- 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
- 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
- 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
- 5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:

1. Substitute item provisions as specified in Document 00700 - General Conditions.

F. Changes and change orders:

1. As specified in Section 01600 - Product Requirements.

## 1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01410 - Regulatory Requirements:
  - a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
2. The following codes and standards are hereby incorporated into this Section:
  - a. American National Standards Institute (ANSI).
  - b. American Petroleum Institute (API):
    - 1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
    - 2) RP 551 - Process Measurement Instrumentation.
  - c. International Organization for Standardization (ISO):
    - 1) 9001 - Quality Management Systems - Requirements.
  - d. International Society of Automation (ISA):
    - 1) 5.1 - Instrumentation Symbols and Identification.
    - 2) 5.4 - Instrument Loop Diagrams.
    - 3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
  - e. National Electrical Manufacturers Association (NEMA):
    - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
  - f. National Fire Protection Association (NFPA).
  - g. National Institute of Standards and Technology (NIST).
  - h. Underwriters Laboratories, Inc. (UL):
    - 1) 508 - Standard of Safety for Industrial Control Equipment.
    - 2) 508A - Standard of Safety for Industrial Control Panels.



- B. Compliance with Laws and Regulations:
1. As specified in Document 00700 - General Conditions.

### 1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
1. Factory Mutual (FM).
  2. International Electrotechnical Commission (IEC).
  3. Institute of Electrical and Electronics Engineers (IEEE).
  4. International Society of Automation (ISA).
  5. International Organization for Standardization (ISO).
  6. National Electrical Code (NEC).
  7. National Electrical Manufacturers Association (NEMA).
  8. InterNational Electrical Testing Association (NETA).
  9. National Fire Protection Association (NFPA).
  10. National Institute of Standards and Technology (NIST).
  11. Underwriters Laboratories (UL).
- B. Specific definitions:
1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
  2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
  3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
  4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
  5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
  6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
    - a. Fieldbus communications signal or both.
  7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
- C. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
  2. Type 2 enclosure in accordance with NEMA 250.
  3. Type 3 enclosure in accordance with NEMA 250.
  4. Type 3R enclosure in accordance with NEMA 250.
  5. Type 3S enclosure in accordance with NEMA 250.



6. Type 3X enclosure in accordance with NEMA 250.
7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 12 enclosure in accordance with NEMA 250.
15. Type 12K enclosure in accordance with NEMA 250.
16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:

1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.
3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
4. DPDT: Double-pole, double-throw.
5. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
6. FAT: Factory acceptance test also known as Source Test.
7. HART: Highway addressable remote transducer.
8. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
10. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
11. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
12. I/O: Input/Output.
13. IP: Internet protocol or ingress protection.
14. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.



16. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
17. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
18. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
19. P&ID: Process and instrumentation diagram.
20. PC: Personal computer.
21. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
22. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
23. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCS/LCPs, VCPs and all data management systems accessible to staff.
24. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SPDT: Single-pole, double-throw.
31. SPST: Single-pole, single-throw.
32. UPS: Uninterruptible power supply.
33. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
34. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.





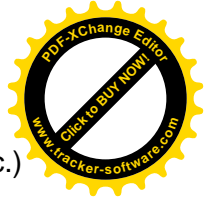
## 1.04 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.
- B. General:
  - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
  - 2. Furnish the submittals required by each section in the Instrumentation Specifications.
  - 3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
    - a. Uniquely number each wire.
    - b. Wire numbers must appear on all Equipment Drawings.
  - 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Submittal organization:
  - 1. First page:
    - a. Specification section reference.
    - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
    - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
    - d. Comments.
    - e. Contractor's review certification statement and signature.
  - 2. Next pages:
    - a. Provide confirmation of specification compliance:
      - 1) Specification section: Include with each submittal a copy of the relevant specification section.
        - a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
        - b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
    - b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
      - 1) In the order that the comments or questions were presented throughout the submittal.
      - 2) Referenced by index section and page number on which the comment appeared.
      - 3) Acceptable responses to Engineer's comments are either:
        - a) Engineer's comment or change is accepted and appropriate changes are made.
        - b) Explain why comment is not accepted or requested change is not made.
        - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
      - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
      - 5) No further review by the Engineer will be performed until a response for previous comments has been received.



3. Remaining pages:
  - a. Actual submittal data:
    - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
    - 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.
- D. Submittal requirements:
  1. Furnish submittals that are fully indexed with a tabbed divider for every component.
  2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
  3. Furnish submittals in the following general order, each in a separate bound set:
    - a. Schedule of Values.
    - b. Product Data.
    - c. After Engineer acceptance of the Product Data, submit the Project Shop Drawing submittals.
    - d. Loop Description Submittal.
    - e. The Process Control Hardware and Software Submittal including, control system software, programming, and screens.
    - f. Testing, Calibration and Process Start-Up procedures.
    - g. Operation and Maintenance Data.
    - h. Training Submittals.
    - i. Record Documents.
  4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
    - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
  5. Submit copies of shop drawings, and product data:
    - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
  6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
    - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
  7. Exceptions to Specifications and Drawings:
    - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
    - c. Acceptance of any exception is at the sole discretion of the Engineer.





- 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
- d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

E. Submittal preparation:

1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
  - a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
  - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

F. Specific submittal requirements:

1. Shop drawings:
  - a. Required for materials and equipment listed in this and other sections.
  - b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
  - c. Shop drawings requirements:
    - 1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
    - 2) Locations of conduit entrances and access plates.
    - 3) Component layout and identification.
    - 4) Schematic and wiring diagrams with wire numbers and terminal identification.
    - 5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
    - 6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
    - 7) Weight.
    - 8) Finish.
    - 9) Nameplates:
      - a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
    - 10) Temperature limitations, as applicable.



- d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
  - e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
    - 1) Uniquely number each wire per the Specifications.
  - f. Wire numbers must appear on all equipment drawings.
  - g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
    - 1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
    - 2) Binder ring size: 2 inches.
  - h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
    - 1) The firm's registered business name.
    - 2) Firm's physical address, email address, and phone number.
    - 3) Owner's name.
    - 4) Project name and location.
    - 5) Drawing name.
    - 6) Revision level.
    - 7) Personnel responsible for the content of the drawing.
    - 8) Date.
  - i. The work includes modifications to existing circuits:
    - 1) Clearly show all modifications to existing circuits.
    - 2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
2. Product data:
- a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
  - b. Include:
    - 1) Catalog cuts.
    - 2) Bulletins.
    - 3) Brochures.
    - 4) Quality photocopies of applicable pages from these documents.
    - 5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
    - 6) Identify model number and options for the actual equipment being furnished.
    - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
  - c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
  - d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
    - 1) Uniquely number each wire per the Specifications.
  - e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
- a. As specified in Section 01782 - Operation and Maintenance Data.



- b. Submit preliminary sets of these manuals to the Engineer for review of format and content:
  - 1) Engineer will return 1 set with comments.
  - 2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Functional Testing of the systems.
- c. Incorporate changes that occur during process start-up and submit as part of the final manuals.
- d. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
- e. Include Record Documents and the accepted shop drawing submittals, modified for conditions encountered in the field during the work.
- f. Include signed results from Functional Testing and Process Operational Period.
- g. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
- h. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
- i. Spare parts list:
  - 1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
    - a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
  - 2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
- j. Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
- k. Additional operation and maintenance manual requirements:
  - 1) Completely index manuals with a tab for each section:
    - a) Each section containing applicable data for each piece of equipment, system, or topic covered.
    - b) Assemble manuals using the accepted shop drawings, and include, the following types of data:
      - (1) Complete set of 11-inch by 17-inch drawings of equipment.
      - (2) Complete set of 11-inch by 17-inch drawings of the control system.
      - (3) Complete set of control schematics.
      - (4) Complete parts list for all equipment being provided.
      - (5) Catalog data for all products or equipment furnished.
- l. Operational Manual:
  - 1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
- m. Control System Software Record Documents:
  - 1) Include complete documentation of all the software programs provided for the entire control and PCS system, including:
    - a) Listings of all application software on both hard copy and DVD, DVD-ROM, and CD-ROM.



- b) Database, both hard copy and DVD, DVD-ROM, and CD-ROM.
    - c) Communication protocols.
    - d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
  - n. Organize the operation and maintenance manuals for each process in the following manner:
    - 1) Section A - Process and Instrumentation Diagrams.
    - 2) Section B - Control Descriptions.
    - 3) Section C - Loop Drawings.
    - 4) Section D - Instrument Summary.
    - 5) Section E - Instrument Data Sheets and Brochures.
    - 6) Section F - Sizing Calculations.
    - 7) Section G - Instrumentation Installation Details.
    - 8) Section H - Test Results.
    - 9) Section I - Operational Manual.
    - 10) Section J - Spare Parts List.
    - 11) Section K - Control System Software.
- 5. Material and equipment schedules:
  - a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
    - 1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- 6. Itemized instrument summary:
  - a. Submit a hard copy of the instrument summary.
  - b. List all of the key attributes of each instrument including:
    - 1) Tag number.
    - 2) Manufacturer.
    - 3) Model number.
    - 4) Service.
    - 5) Area location.
    - 6) Calibrated range.
    - 7) Loop drawing number.
  - c. Associated LCS/LCP, VCP, PCM, or PLC.
- 7. Instrument data sheets and cut sheets:
  - a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
    - 1) Component functional description specified in this Section and indicated on the Drawings.
    - 2) Manufacturers model number or other product designation.
    - 3) Tag number specified in this Section and indicated on the Drawings.
    - 4) System or loop of which the component is a part.
    - 5) Location or assembly at which the component is to be installed.
    - 6) Input and output characteristics, including digital bus communication.
    - 7) Scale range with units and multiplier.
    - 8) Requirements for electric supply.
    - 9) Requirements for air supply.



- 10) Power consumption.
- 11) Response timing.
- 12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
- 13) Special requirements or features, such as specifications for ambient operating conditions.
- 14) Features and options that are furnished.
- b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
  - 1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
  - 2) Include a list of tag numbers for which it applies with each brochure or bulletin.
  - 3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
  - 4) Cross out models, features, options, or accessories that are not being provided.
  - 5) Clearly mark and identify special options and features.
- c. Organization: Index the data sheets and brochures in the submittal by systems or loops.
8. Control panel hardware submittal:
  - a. Submit the following in 1 submittal package.
  - b. Complete and detailed bills of materials:
    - 1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
    - 2) Include all items within an enclosure.
  - c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
  - d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
  - e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
  - f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
    - 1) The manufacturer's model number or other identifying product designation.
    - 2) Tag and loop number.
    - 3) System to which it belongs.
    - 4) Site to which it applies.
    - 5) Input and output characteristics.
    - 6) Requirements for electric power.
    - 7) Device ambient operating requirements.
    - 8) Materials of construction.
9. Schedule of values:
  - a. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express



purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

10. Installation recommendations:
  - a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
11. Training submittals:
  - a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
  - b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
  - c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
  - d. Training course plan submittals:
    - 1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01756 - Commissioning.
    - 2) Describe any student pre-requisites for the course or training activity.
    - 3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
    - 4) Submit training materials.
  - e. Incorporate all submittal review comments into the course.
  - f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
12. Project Record documents:
  - a. Furnish as specified in Section 01770 - Closeout Procedures.
  - b. Record Drawing requirements:
    - 1) Provide Project Record Drawing of all Instrumentation Drawings.
    - 2) Update Record Drawings weekly.
    - 3) Record Drawings must be fully updated as a condition of the monthly progress payments.
    - 4) Clearly and neatly show all changes including the following:
      - a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
  - c. Shop drawings:
    - 1) General:
      - a) Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:





- (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
- b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders, digital bus network equipment, and other equipment related to the PCS.
- c) Generate all drawings developed for this project utilizing AutoCAD by Auto Desk Version 2012 or later:
  - (1) Furnish on CD-ROM disks containing the following for each drawing:
    - (a) Original CAD files in DWG format.
    - (b) PDF version.
  - (2) Provide hard copies on 11-inch by 17-inch plain bond paper.
- d) Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
  - (1) Should an error be found in a shop drawing during installation or process start-up of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
  - (2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
  - (3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using plain bond paper.
  - (4) Provide electronic copies of these documents on CD-ROM disks in AutoCAD DWG 2010 format or later and PDF format. Size all drawings to be readable and legible on 11-inch by 17-inch media.
- e) Submittal Documents:
  - (1) Provide an interim submittal of Record Documents after the PCS system Functional Testing.
  - (2) Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01782 - Operation and Maintenance Data or the General Requirements.
- f) Review and Corrections:
  - (1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
  - (2) Promptly correct and re-submit Record Documents returned for correction.
- 2) Furnish written information prepared specifically for this Project using Microsoft Word and PDF formats and printed on 8.5-inch by 11-inch plain bond paper:
  - a) Provide electronic copies of these documents on CD-ROM disks.



- d. Review and corrections:
  - 1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
  - 2) Promptly correct and re-submit record documents returned for correction.
- 13. Loop Drawings:
  - a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
    - 1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
    - 2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
    - 3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
  - b. Show every instrument and I/O point on at least one loop diagram.
  - c. Provide a complete index in the front of each bound volume:
    - 1) Index the loop drawings by systems or process areas.
  - d. Provide drawings showing definitive diagrams for every instrumentation loop system:
    - 1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
    - 2) Furnish a separate drawing sheet for each system or loop diagram.
  - e. In addition to the ISA-5.4 requirements, show the following details:
    - 1) Functional name of each loop.
    - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
    - 3) Show all terminal numbers, regardless of the entity providing the equipment.
    - 4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
    - 5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
    - 6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
    - 7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
  - f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.
- 14. Instrument Installation Drawings:
  - a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
  - b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.





- c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
  - d. For each detail, provide, as a minimum, the following contents:
    - 1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
    - 2) Ambient temperature and humidity where the instrument is to be installed.
    - 3) Corrosive qualities of the environment where the instrument is to be installed.
    - 4) Hazardous rating of the environment where the instrument is to be installed.
    - 5) Process line pipe or tank size, service and material.
    - 6) Process tap elevation and location.
    - 7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
    - 8) Routing of tubing and identification of supports.
    - 9) Mounting brackets, stands, anchoring devices, and sun shades.
    - 10) Conduit entry size, number, location, and delineation between power and signal.
    - 11) NEMA ratings of enclosures and all components.
    - 12) Clearances required for instrument servicing.
    - 13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
15. Control Panel Drawings:
- a. Layout Drawings:
    - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
    - 2) As a minimum, include the following information:
      - a) To scale front, side, and plan views.
      - b) Dimensions.
      - c) Interior and exterior arrangements.
      - d) Mounting information, including conduit entrance location.
      - e) Finish data.
      - f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
      - g) Nameplate legend including text, letter size, materials, and colors.
  - b. Wiring and piping diagrams:
    - 1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
    - 2) Include the following information:
      - a) Name of panel.
      - b) Wiring and piping sizes and types.
      - c) Terminal strip numbers.
      - d) Wire tags and labels.
      - e) Functional name and manufacturer's designation for items to which wiring and piping are connected.



- f) Electrical control schematics in accordance with ANSI standards.
  - c. Installation drawings:
    - 1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
    - 2) Provide scaled drawings and show the position of the equipment at its intended installation location.
    - 3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
    - 4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
- 16. Schematic Diagrams:
  - a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
  - b. Include device and field connection terminal numbers on all schematic diagrams.
  - c. Incorporate equipment manufacturer's shop drawing information into the schematic diagrams in order to document the entire control system.
- 17. Control System Diagram:
  - a. Submit a complete set of control system diagrams including the following information:
    - 1) All PLCs, workstations, printers, communication devices, and communication links:
      - a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
    - 2) All cables required for communication requirements.
    - 3) Show each component fully annotated with conduit size and number associated with the power source.
- 18. Process Control Software Submittal:
  - a. In accordance with Product Data and Shop Drawing general requirements.
  - b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
    - 1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
  - c. A complete listing of the PCS system point I/O database:
    - 1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
    - 2) Organize on a site-by-site basis, separate by point type.
    - 3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
    - 4) Upon completion of the Work, update all I/O lists to indicate the final as-built configuration of the systems:
      - a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.



- d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
- e. Preliminary overview, screens, station graphic displays, and preliminary reports.
- 19. Instrumentation and Control System Contractor Statement of Qualifications:
  - a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
- 20. Control Descriptions:
  - a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
    - 1) Include all functions depicted or described in the Contract Documents.
    - 2) Include within the Control Description content:
      - a) All specific requirements.
      - b) All common requirements that pertain in general to all loops.
      - c) Listing all ranges, setpoints, timers, values, counter values, etc.
- 21. Test Procedure Submittals:
  - a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
    - 1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
    - 2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
- 22. Test reports:
  - a. As specified in Section 01330 - Submittal Procedures.

## **1.05 QUALITY ASSURANCE**

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. ICSC qualifications:
  - 1. General information on the proposing company:
    - a. Document that the ICSC Company has been actively involved in the instrumentation, PLC-based control systems business for a minimum of five years and has adequate facilities, organization structure, manpower, and technical and managerial expertise to properly perform the Work as specified in these Specifications.
  - 2. Document that the ICSC has a qualified permanent service facility:
    - a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and process start-up all of the instrumentation, control, telemetry, SCADA and control systems hardware and software furnished under this Contract, including remote diagnostic capability.
    - b. Document in-house resource of permanent personnel experienced in the design and programming of equipment and systems as specified in these Specifications.
    - c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.



- d. Document that the firm is a recognized or certified “system integrator partner” or similar designation for the control software and PLC system being supplied for this Project.
    3. Similar project experience of the company:
      - a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring and panel assembly drawings), software configuration and documentation, field testing, calibration and process start-up, operator instruction, and maintenance training. In addition, provide the following information for each project:
        - 1) Name of plant or system owner, contact name, and current telephone number. Design engineer’s name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for prequalification.
        - 2) Manufacturer and model number(s) of the PLC based control system and the computer-based SCADA system used for both hardware and software.
        - 3) Brief description of the system.
        - 4) Approximate number of input and output signals: analog, digital, and fieldbus.
        - 5) Brief application software description.
        - 6) Contracted cost of the system, separate by base amount and any change orders for the completed projects.
        - 7) Duration of the project and date of completion.
    4. Information on the proposed Project team members:
      - a. Provide the name and resume of the individual persons who will be responsible for each of the following:
        - 1) Office engineering and management of this Project.
        - 2) Lead for software configuration/programming.
        - 3) Individual who will be responsible for the hardware and hardware interface design.
        - 4) Individual who will be responsible for field testing, calibration, and process start-up.
        - 5) Individual who will be responsible for operator training.
      - b. All of these individuals must be permanent employees of the proposing firm.
    5. Determination of the proposed ICSC qualifications is at the sole discretion of the Engineer.
  - C. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
  - D. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.
  - E. ICSC:



1. Contractor, through the use of a qualified ICSC, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system including application software, for a complete, integrated and functional PCIS system.
3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 01600 - Product Requirements.
- B. Special instructions:
  1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
- C. Tagging:
  1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
  2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
  3. Tag instruments immediately upon receipt in the field.
  4. Prominently display identification on the outside of the package.
  5. Utilize the Tag and Loop Number identifications shown on the P&IDs.
- D. Delivery and inspection:
  1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. Site conditions:
  1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
  2. Seismic classification:
    - a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612 - Seismic Design Criteria.
  3. Wind:
    - a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614 - Wind Design Criteria.
  4. Altitude, temperature and humidity:
    - a. As specified in Section 01610 - Project Design Criteria.



- b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
- c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
  - 1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
- 5. Area classifications:
  - a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.

## 1.08 SEQUENCING

- A. General:
  - 1. As specified in Section 01312 - Project Meetings and Section 01756 - Commissioning.
  - 2. Testing requirements are specified in Section 01756 - Commissioning and Section 17950 - Commissioning for Instrumentation and Controls.
  - 3. General scheduling requirements are specified in Section 01321 - Schedules and Reports.
  - 4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
  - 5. Commissioning requirements as specified in Section 01756 - Commissioning.
- B. Pre-submittal conferences:
  - 1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
  - 2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
    - a. Vendor control panels.
    - b. Chemical feed systems.
    - c. Motor control centers.
    - d. Switchgear.
    - e. Variable frequency drives.
    - f. Lighting.
    - g. Engine generators.
- C. General Field Start-Up and testing procedures:
  - 1. As specified in Section 01756 - Commissioning.
- D. Installation testing:
  - 1. As specified in Section 01756 - Commissioning.
  - 2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.





3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.

E. Training:

1. As specified in Section 01756 - Commissioning.

F. Functional testing:

1. Representatives from each of the following groups shall be in attendance during the functional Testing: Programmer. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
2. Loop validation test.
3. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
  - a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
  - b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
  - c. Loop validation certifications:
    - 1) After the field device loop tests have been successfully completed as specified in Section 17950 - Commissioning for Instrumentation and Controls for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
      - a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

- G. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.

H. Process Operational Period:

1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

## **1.09 SCHEDULING (NOT USED)**

## **1.10 WARRANTY**

- A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in Documents 00700 - General Conditions and 00712 - Supplementary Conditions.



## **1.11 SYSTEM PROCESS START-UP**

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
  - 1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

## **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.13 MAINTENANCE**

- A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by the Contract Documents.
- C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.
- D. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.
- B. Allowable manufacturers are specified in individual instrument and equipment specifications.

### **2.02 SYSTEM DESCRIPTION**

- A. General requirements:
  - 1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
    - a. Preparing hardware submittals for field instrumentation.
    - b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
    - c. Prepare the test plan, the training plan, and the spare parts submittals.
    - d. Procure all hardware.
    - e. Fabricate panels.
    - f. Perform factory tests on panels.
    - g. Perform bench calibration and verify calibration after installation.





- h. Oversee and certify installation of the PCS system.
  - i. Oversee, document, and certify loop testing.
  - j. Oversee, document, and certify system.
  - k. Installation Testing.
  - l. Oversee and document Functional Testing.
  - m. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
  - n. Prepare operation and maintenance manuals.
  - o. Conduct training classes.
  - p. Integrate the PCS with instrumentation and control devices provided under other sections.
  - q. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
    - 1) As specified in the Contract Documents.
    - 2) For Owner furnished items.
    - 3) For interfaces with existing equipment.
  - r. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
  - s. Perform all required corrective and preventative maintenance.
- 2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
  - 3. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
  - 4. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.
  - 5. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
  - 6. Defective Work:
    - a. As specified in Document 00700 - General Conditions.

### **2.03 EXISTING PRODUCTS (NOT USED)**

### **2.04 MATERIALS**

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.



- B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

## **2.05 MANUFACTURED UNITS (NOT USED)**

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS**

- A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.
- B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.
- C. Signal transmission:
1. Analog signals:
    - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
    - b. Furnish electrical analog signals outside control panels that are 4-to-20 milliamperes 24 VDC, except as indicated.
    - c. Electrically or optically isolate all analog signals from other signals.
    - d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
    - e. Maintain the total 4-to-20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
    - f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
  2. Discrete input signals:
    - a. As indicated in the controller hardware specification.
  3. Discrete output signals:
    - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
    - b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
    - c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
    - d. Provide interposing relays as required for functionality of the control circuit.
  4. Signal performance and design criteria:
    - a. Stability:
      - 1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
    - b. Response:
      - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.



- c. Agreement:
  - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
- d. Repeatability:
  - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
- e. Sensitivity:
  - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
- f. Performance:
  - 1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:

- 1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
- 2. Alarm contacts: Fail to the alarm condition.
- 3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:

- 1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
- 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
- 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
- 4. Terminate the signal cable shield on a dedicated grounding terminal block.
- 5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

## 2.08 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.
- B. Nameplates:
  - 1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
  - 2. All nameplates shall be of identical style, color, and material throughout the facility.
  - 3. Device nameplates shall include:
    - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
      - 1) Device tag and loop number ID (e.g., FIT-60.011).
      - 2) PLC ID (e.g., PLC-11).
      - 3) Power information (e.g., PCM-11, 120 VAC).



- b. White lettering on a black background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL**

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.
- B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
  1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.
- C. Source Test is specified in Section 17950 - Commissioning for Instrumentation and Controls.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION**

- A. The ICSC is encouraged to attend a pre-bid conference and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.
- B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
- C. Provide a complete instrumentation and control system:
  1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
  1. Verify all dimensions as indicated on the Drawings:
    - a. Actual field conditions govern all final installed locations, distances, and levels.



2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
  3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.
- C. The PCIS configurations are diagrammatic:
1. The locations of equipment are approximate unless dimensioned.
  2. Where Project conditions require, make reasonable changes in locations and arrangements.
- D. Field instruments installation:
1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
  2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
    - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
    - b. Provide sun shields for all field electronic instruments located outdoors.
  3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
    - a. Type of flexible conduit required for the area classification:
      - 1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
    - b. Maximum length of 18 inches.
  4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
    - a. Special cable applications shall be in accordance with the NEC.
  5. Verify the correctness of each installation:
    - a. Polarity of electric power and signal connections.
  6. Ensure all process connections are free of leaks.
  7. Provide a power disconnect switch for each 120 VAC powered instrument which does not have a built-in power disconnect:
    - a. Disconnect enclosure suitable for the area classification:
      - 1) As specified in Section 16050 - Common Work Results for Electrical.
- E. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
  2. All control panels, LCS/VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- F. Instrument tagging:
1. As specified in Section 16075 - Identification for Electrical Systems.
  2. Provide all field-mounted instruments with nameplates:



- a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
      - 1) Affix tags with stainless steel wire fasteners.
  3. Provide all back of panel instruments with nameplates:
    - a. Engraved with the instrument's full tag number as indicated on the Drawings:
  4. Provide all front of panel instruments with a nameplate:
    - a. Engraving to include the following:
      - 1) Instrument's full tag number.
      - 2) Service description.
    - b. Nameplates:
      - 1) Secure nameplates to the panel with stainless steel screws.
      - 2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.
- G. Cable and conductor termination:
  1. Terminate all cables and conductors on terminal blocks.
  2. Terminal block enclosures:
    - a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.
- H. Surge protection:
  1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
  2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/2-ampere fuse between power supplies and receiver surge protectors.
  3. Provide voltage surge protection for 4 wire transmitters and analyzers:
    - a. Protect both power source and signal loop.

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 COMMISSIONING**

- A. As specified in Section 01756 - Commissioning.
- B. Owner Training:
  1. Demonstration requirements are specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.08 FIELD QUALITY CONTROL**

- A. Inspection:
  1. Allow for inspection of PCIS installation as specified in Section 01450 - Quality Control.
  2. Provide any assistance necessary to support inspection activities.
  3. Engineer inspections may include, but are not limited to, the following:
    - a. Inspect equipment and materials for physical damage.
    - b. Inspect installation for compliance with Drawings and Specifications.



- c. Inspect installation for obstructions and adequate clearances around equipment.
- d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
- e. Inspect equipment nameplate data to verify compliance with design requirements.
- f. Inspect cable terminations.
- g. Inspect/witness instrument calibrations/verifications.
- 4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Instrument Installation Inspection:

- 1. Provide any assistance necessary to support inspection activities.
- 2. Inspections may include, but are not limited to, the following:
  - a. Inspect equipment and materials for physical damage.
  - b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
  - c. Inspect installation for compliance with Drawings and Specifications.
  - d. Inspect installation for obstructions and adequate clearances around equipment.
  - e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
  - f. Inspect equipment nameplate data to verify compliance with design requirements.
  - g. Inspect cable terminations.
  - h. Inspect/witness instrument calibrations/verifications.
- 3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.
- 4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Commissioning for Instrumentation and Controls. Additional general requirements are specified in Section 01756 - Commissioning.

C. Installation supervision:

- 1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
  - a. Installation resources:
    - 1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
  - b. Provide technical assistance to installation personnel by telephone:
    - 1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
  - c. Periodic inspections during the construction period.
  - d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
  - e. Field verify accuracy and calibration of all instruments.





3.09

## **ADJUSTING**

- A. Control valves:
  - 1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
  - 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.
- B. Make all revisions necessary to the control system software, as directed by the Engineer.
  - 1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

## **3.10 CLEANING**

- A. As specified in Section 01770 - Closeout Procedures.
- B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.
- C. Clean all panel surfaces.
- D. Return to new condition any scratches and/or defects.
- E. Wipe all instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
  - 1. Neatly coil and label all spare wiring lengths.
  - 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.
- G. As specified in other sections of the Contract Documents.

## **3.11 PROTECTION**

- A. Protect all Work from damage or degradation until date of Substantial Completion.

## **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 17100

### CONTROL STRATEGIES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Contractor-developed loop description submittal requirements.
  - 2. General programming requirements.
  - 3. Common control functions:
    - a. General control and monitoring functions to be provided throughout the PCS system.
      - 1) These requirements apply to all systems, and supplement the specific loop descriptions in Section 17101 - Specific Control Strategies and information indicated on the Drawings.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
- C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.
- D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.
- E. Slew rate: Rate of change in respect to time.
- F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.
- G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



**1.06 QUALITY ASSURANCE (NOT USED)**

**1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)**

**1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

**1.09 SEQUENCING (NOT USED)**

**1.10 SCHEDULING (NOT USED)**

**1.11 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

**1.12 SYSTEM START-UP (NOT USED)**

**1.13 OWNER'S INSTRUCTIONS (NOT USED)**

**1.14 COMMISSIONING (NOT USED)**

**1.15 MAINTENANCE (NOT USED)**

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS (NOT USED)**

**2.02 EXISTING PRODUCTS (NOT USED)**

**2.03 MATERIALS (NOT USED)**

**2.04 MANUFACTURED UNITS (NOT USED)**

**2.05 EQUIPMENT (NOT USED)**

**2.06 COMPONENTS (NOT USED)**

**2.07 ACCESSORIES (NOT USED)**

**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL (NOT USED)**

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**



### 3.03 INSTALLATION (NOT USED)

### 3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. General programming requirements:
  - 1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
    - a. Submit names for Owner approval.
    - b. Unless otherwise noted, utilize floating-point format for all PLC algorithms and calculations.
    - c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
  - 2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
  - 3. Reusable PLC code blocks:
    - a. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
    - b. New code blocks that the Contractor would like to use as a standard shall be submitted to Owner for review and approval.
  - 4. Documentation:
    - a. All control logic shall be completely annotated including all rungs, instructions, and tags.
    - b. Each routine shall have a title and a detailed description of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description.
    - c. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
    - d. Digital tag descriptions shall include the On and Off state labels.
    - e. Complete, grammatically correct sentences and terminology, consistent with water treatment processes, shall be utilized in the development of rung and routine descriptions.
    - f. All equations developed in the process logic shall be fully documented in the rung or routine description. A description of each constant and variable utilized in the equation shall be defined including engineering units.
  - 5. Program slew rates for setpoints to limit the effect of updated setpoints on the process:
    - a. Provide for control setpoints and manual speed and position selections.
    - b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
    - c. Provide operator access to change slew rates from the HMI.
  - 6. Saved setpoints:
    - a. Provide an operator selection to save all setpoint values.
    - b. Where possible use a DFB or AOI to provide an operator selection to restore all setpoints to the initial start-up value.



- c. Provide an operator selection to restore all setpoints to the last saved value.
- 7. Store a copy of all adjustable parameters and accumulated and integrated totals in PCS:
  - a. Upon re-loading of the PLC program, re-load these values to the PLC from PCS or processor memory card.
  - b. PLCs provide a minimum 2 week data storage to provide for data accumulation and later communication to the Historian in the event of a network interruption.
- 8. Calculated values:
  - a. Program calculations such that division by zero errors cannot occur.
  - b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
  - c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
  - d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years. Utilize manufacturer AOI/DFBs etc. where possible.
- 9. Timers:
  - a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
    - 1) The settling timers may be overridden by setting the timer to 0 seconds.
- 10. Control Panel status:
  - a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
    - 1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
  - b. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including but not limited to the following:
    - 1) PLC cabinet over-temperatures from high temperature switch.
    - 2) Intrusion status on all enclosures equipped with intrusion switches.
    - 3) AC power failure:
      - a) Monitor ahead of UPS.
    - 4) DC power supply failure:
      - a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
    - 5) UPS failure signal.
    - 6) UPS Low Battery signal.
    - 7) Digital bus network Coupler and or Gateway failure signal.
    - 8) Ethernet Switch failure signal.
- 11. PLC system communication status:
  - a. Furnish a minimum of 1 screen to display all communication errors and status within the PCS:
    - 1) Communication between PCS and PLCs, PLC to PLC, PLC to RIO and PLC and or PCS to VCP.
    - 2) 4-20 mA HART interface cards.



- 3) Digital bus network status:
    - a) Profibus scanners.
    - 4) Modbus Gateway modules.
    - 5) Display status of each node, and summary of failures over the past 60 minutes.
  - b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
  - c. In the event of communications loss:
    - 1) Continue normal operation at each PLC.
    - 2) Where control parameters are received over a communications link:
      - a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
        - (1) Ensure that the operator can control the process using PC\IS HAND mode at the local LOI.
      - b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
        - (1) Provide a manual over-ride entry at the local LOI to allow an operator to enter a different value for any such remote signal.
        - (2) Generate an alarm whenever an over-ride value is in use.
12. 4-20 mA Hart interface cards:
- a. Provide the following HART protocol information for each populated channel on the card:
    - 1) Process variable values:
      - a) Primary process variable (analog): 4-20 mA current signal.
      - b) Primary process variable (digital): Digital value in engineering units.
      - c) Percent range: Primary process variable expressed as percent of calibrated range.
      - d) Loop current: Loop current value in milliamps.
      - e) Secondary process Variable 1: Digital value in engineering units available from multivariable devices (if applicable).
    - 2) Host commands:
      - a) Set primary variable units.
      - b) Set upper range.
      - c) Set lower range.
      - d) Set damping value.
      - e) Set message.
      - f) Set tag.
      - g) Set date.
      - h) Set descriptor.
      - i) Perform loop test: Force loop current to specific value.
      - j) Initiate self-test: Start device self-test.
      - k) Get more status available information.
    - 3) Status and diagnostic alerts:
      - a) Device malfunction: Indicated device self-diagnostic has detected a problem in device operation.



- b) Configuration changed: Indicates device configuration has been changed.
- c) Cold start: Indicates device has gone through power cycle.
- d) More status available: Indicates additional devices status data available.
- e) Primary variable analog output fixed: Indicates device in fixed current mode.
- f) Primary variable analog output saturated: Indicates 4-20 mA signal is saturated.
- g) Secondary variable out of limits: Indicates secondary variable value outside the sensor limits.
- h) Primary variable out of limits: Indicates primary variable value outside the sensor limits.
- 4) Device identification:
  - a) Instrument tag: User defined, up to 8 characters.
  - b) Descriptor: User defined, up to 16 characters.
  - c) Manufacturer name (code): Code established by HCF and set by manufacturer.
  - d) Device type and revision: Set by manufacturer.
  - e) Device serial number: Set by manufacturer.
  - f) Sensor serial number: Set by manufacturer.
- 5) Calibration information:
  - a) Date: Date of last calibration, set by user.
  - b) Upper range value: Primary variable value in engineering units for 20 mA point, set by user.
  - c) Lower range value: Primary variable value in engineering units for 4 mA point, set by user.
  - d) Upper sensor limit: Set by manufacturer.
  - e) Lower sensor limit: Set by manufacturer.
  - f) Sensor minimum span: Set by manufacturer.
  - g) PV damping: Primary process variable damping factor, set by user.
  - h) Message: Scratch pad message area (32 characters), set by user.
  - i) Loop current transfer function: Relationship between primary variable digital value and 4-20 mA current signal.
  - j) Loop current alarm action: Loop current action on device failure (upscale/downscale).
  - k) Write protect status: Device write-protect indicator.

C. Common control functions:

- 1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
- 2. Alarms:
  - a. Generate alarms within the PLC logic.
  - b. Indicate alarms at the LOI and HMI. Enable acknowledgement from either the HMI or the LOI.
  - c. Generate high, high-high, low, and low-low level alarms where indicated:
    - 1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.



- 2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
    - d. Flash all alarm and fail conditions and their respective indicators on the PCS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
    - e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
      - 1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
    - f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
    - g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
      - 1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
      - 2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
    - h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
    - i. Furnish an alarm silence pushbutton at each PCM, LOI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
    - j. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
      - 1) The lamp test may sequence through blocks of lights.
      - 2) Minimum on time for each lamp during lamp test 15 seconds.
    - k. Horns and Beacons:
      - 1) Activate PCM horn and beacon on all critical alarms and on other alarms as defined by the Facility Alarm Philosophy.
      - 2) Deactivate PCM horn and beacon when PCM reset pushbutton is activated.
      - 3) Silence PCM horn when PCM silence pushbutton is activated.
    - l. Dual analog instruments:
      - 1) For applications where 2 or more analog instruments are measuring the same process variable:
        - a) Generate an operator adjustable percent deviation alarm.
        - b) Allow operator to take each instrument out of service when an instrument is out of service.
3. Where a reset is shown for counts, totals and times maintained in the PLC:
  - a. Provide a reset selection on the HMI screen that displays the value.
  - b. Provide a preset function on the HMI to allow an operator-entered value to become the current accumulated total.
  - c. Limit access to the reset and preset functions to operators with suitable security level.
  - d. Log the value before reset, operator, time, and date of reset in the PCS archive.
  - e. Log the value before preset, preset value, operator, time, and date of preset in the PCS archive.





4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
  - a. Display total starts on PCS screens, and provide a reset function.
  - b. Where indicated, calculate number of starts for each day:
    - 1) Display current day and previous day starts on PCS displays.
    - 2) Do not reset daily start count when overall count is reset.
    - 3) Archive starts for each day through PCS.
5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
  - a. Display total run time in hours on PCS screens.
  - b. Where indicated, calculate total run time for each day:
    - 1) Display current day and previous day run time on the HMI to the nearest 0.1 hour.
    - 2) Do not reset daily run time when overall time is reset.
    - 3) Archive run time for each day through PCS.
6. For all monitored analog values:
  - a. Convert all values to engineering units in floating-point format within the PLC.
  - b. Flows and Weights:
    - 1) Totalize flows in the PLC logic:
    - 2) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
    - 3) Where no totalizer input is shown, integrate the analog input over time.
    - 4) Display totals on the HMI and LOI.
    - 5) Archive totals to the historical database through PCS.
  - c. Generate an alarm whenever an over-ride value is in use.
  - d. Calculate hourly, daily, and monthly averages:
    - 1) Calculations shall be performed by the PLC.
    - 2) Display averages on the HMI, and archive through PCS.
  - e. Calculate minimum and maximum values each day, and month:
    - 1) Calculations may be performed by the PLC or PCS.
    - 2) Display minima and maxima on the HMI, and archive through PCS.
  - f. Generate an alarm whenever an over-ride value is in use.
7. Analog data processing:
  - a. Engineering units conversion:
    - 1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
  - b. Analog magnitude checking:
    - 1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.
8. Tank and vessel levels:
  - a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
    - 1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
  - b. Monitor rate of change of volume on all tanks and vessels:
    - 1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output).





- Generate an alarm whenever the volume decreases faster than this rate.
- 2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.
9. I/O filtering and processing:
- a. Analog input filtering:
    - 1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
    - 2) Monitor analog input signal quality:
      - a) Over range: The input value is above the normal range (typically over 21 mA).
      - b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
      - c) Generate alarms for over or under range inputs.
      - d) Do not use over or under range values for control or calculation purposes:
        - (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
    - 3) Digital input filtering (proving timer):
      - a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
      - b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
10. Instrument scaling (HMI/LOI):
- a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
    - 1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
11. PCS HAND-OFF-AUTO:
- a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCS, accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
    - 1) PCS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
    - 2) PCS HAND: Enables PCS Manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
    - 3) PCS OFF: Automated PCS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.



- 4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.
12. Interlocks:
  - a. Implement software interlocks where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS HAND:
13. Permissives:
  - a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
  - b. Apply software permissives when equipment is operating in PCS AUTO or PCS HAND.
14. Process control algorithms:
  - a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
    - 1) When the error between process variable and setpoint is beyond a setpoint deadband:
      - a) Jog valve or ramp speed in the required direction for a preset "Jog Time" or until the process variable reaches or passes the setpoint.
      - b) Then hold speed or position through a setpoint "Hold Time."
      - c) Continue alternating jog and hold until the error is less than the deadband.
    - 2) Provide operator access to Jog Time and Hold Time setpoints from the HMI.
  - b. PID algorithms: Use where indicated, or where necessary to provide fast response:
    - 1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
      - a) Display Output, CV.
      - b) Display Setpoint, SP.
      - c) Display Process Variable, PV.
      - d) Allow for operator selection of Automatic or Manual control of the output.
      - e) Under Manual control of output allow the operator to enter the desired output value.
      - f) Allow for input of the 3 Proportional, Integral, and Derivative tuning parameters.
      - g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCS), or when the equipment has reached a physical limit.
      - h) When controlled equipment is being operated in remote PCS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.



- i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
- 15. Equipment alternating and sequencing:
  - a. Distribute number of starts and run time equally between identical equipment.
- 16. Motor control:
  - a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
    - 1) Display current REMOTE status on the PCS screens.
  - b. Monitor the device's running status from the starter auxiliary or run status input:
    - 1) Display the current status (running or stopped) on the PCS screens.
    - 2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
    - 3) Provide time stamp for each start.
    - 4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
  - c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCS AUTO or PCS HAND control modes based upon operator selection using the PCS screens.
  - d. Starting, stopping and running when the device LOR is in LOCAL:
    - 1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
    - 2) With the LOR switch in the OFF position, the motor is prohibited from running.
    - 3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
  - e. Starting, stopping and running when the device LOR is in REMOTE:
    - 1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
      - a) Provide "Control Activation" timers for each piece of controlled equipment:
        - (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
          - (a) De-activate the output.
          - (b) Place the device in a "Failed" state.
          - (c) Generate a "Failed to Respond" alarm.
    - 2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
      - a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
        - (1) Keep the RUN output off or the STOP output on.
        - (2) Place the device in a "Failed" state.



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- operating speed should be approximately the same as flow of one pump at Start Next speed).
- (3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.
  - (4) Operate all equipment at the same speed following the output of the speed control algorithm.
- d) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:
- (1) Where flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:
    - (a) Determine initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.
  - (2) When the “Stop Next” condition exists through a preset time delay:
    - (a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
    - (b) Operate all remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.
17. Gate and valve control:
- a. Monitor the device's LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
    - 1) Display current REMOTE status on PCS screens.
  - b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS HAND):
    - 1) Initially set “Open Activation” time to twice the normal opening time.
    - 2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:
      - a) De-activate the open output.
      - b) Place the device in a “Failed” state.
      - c) Generate a “Failed to Open” alarm.
  - c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCS AUTO, or CLOSE was selected in PCS HAND):
    - 1) Initially set “Close Activation” time to twice the normal closing time.
    - 2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:
      - a) De-activate the close output.



- b) Place the device in a "Failed" state.
  - c) Generate a "Failed to Close" alarm.
- d. Limit the number of open/close /commands so that it does not exceed the manufacturer requirements.
- e. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a "Position Error" timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
  - 1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
  - 2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
  - 3) Initially set the "Position Error" time to 60 seconds.
  - 4) If the LSR position does not change, and position error stays outside of the setpoint error through the "Position Error" time period:
    - a) Place the device in a "Failed" state.
    - b) Generate a "Position Fail" alarm.
- f. Provide separate time delay settings for each function and for each device.
- g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a "Failed" state and generate an "Invalid State" alarm.
- h. Re-establish PLC control of a device in a "Failed" state only after one of the following:
  - 1) An operator turns the device's LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
- i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
- j. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) per hour in the PLC:
  - 1) Display count on the HMI.

### **3.05 REPAIR/RESTORATION (NOT USED)**

### **3.06 RE-INSTALLATION (NOT USED)**

### **3.07 FIELD QUALITY CONTROL (NOT USED)**

### **3.08 ADJUSTING (NOT USED)**

### **3.09 CLEANING (NOT USED)**



### **3.10 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.11 PROTECTION (NOT USED)**

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION







## SECTION 17101

### SPECIFIC CONTROL STRATEGIES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Loop descriptions:
    - a. Specific control requirements and functional descriptions for individual control loops.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
    - a. Include all functions depicted or described in the Contract Documents.
    - b. Include the following within each loop description:
      - 1) All requirements specific to that loop.
      - 2) Common control requirements applicable to that loop.
      - 3) List of all ranges, setpoints, timers, values, counters, etc.
  - 2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.
  - 3. Loop description format: As specified in this Section.
- B. Loop number and title.
  - 1. References:
    - a. List P&IDs that are specifically referenced.
  - 2. Abstract:
    - a. General description of how the loop works, what devices are involved, and how the process will be controlled.
    - b. Process values, setpoints, and limits, including units and ranges:
      - 1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.



3. Hardwired control:
  - a. Detailed description of the control functions at the local level.
  - b. Function of local operator interfaces.
  - c. Operation of hardwired field pilot controls:
    - 1) Pushbuttons.
    - 2) Selector switches.
    - 3) Potentiometers.
    - 4) Pilot lights, indicators, and other displays.
4. Hardwired interlocks:
  - a. Explanation of the operation of system interlocks and hardwired permissive conditions.
5. PLC control:
  - a. Detailed description of the control functions that are under control of the PLC.
  - b. Operator controls and automatic controls.
  - c. Setpoints, alarms, etc.:
    - 1) Include units and ranges for analog values.
    - 2) Include span and range for analog inputs and outputs.
    - 3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
  - d. Control sequences.
  - e. Software interlocks:
    - 1) Operation of system software interlocks.
6. PCS/LOI/HMI control:
  - a. Detailed description of the operator controls.
  - b. Setpoints, alarms, etc.
7. Indicators and alarms:
  - a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.
8. Failure modes:
  - a. List any failure modes specific to the loop that are not covered in the common control strategies.

**1.06 QUALITY ASSURANCE (NOT USED)**

**1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)**

**1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

**1.09 SEQUENCING (NOT USED)**

**1.10 SCHEDULING (NOT USED)**

**1.11 WARRANTY (NOT USED)**

**1.12 SYSTEM START-UP (NOT USED)**

**1.13 OWNER'S INSTRUCTIONS (NOT USED)**

**1.14 COMMISSIONING (NOT USED)**

**1.15 MAINTENANCE (NOT USED)**



## **PART 2 PRODUCTS (NOT USED)**

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION (NOT USED)**

### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION**

- A. Loops PMP-111, PMP-121 and PMP-131, PMP-141 - Digester No. 5 and No. 6 Sludge Mixing Pumping System
  - 1. References:
    - a. Drawing 10N01 – Digester No. 5
    - b. Drawing 10N02 – Digester No. 6
  - 2. Abstract:
    - a. Digester mixing pumps circulate and mix sludge in the digester.
    - b. Each digester mixing system includes two duty pumps. The digester mixing system can operate with one duty pump when the second pump is out of service.
    - c. The mixing pumps withdraw sludge from the center of the digester through a common suction header. The mixing pumps discharge sludge through mixing nozzles connected to a common discharge header.
    - d. PMP-111 and –121 mix sludge in Digester No. 5
    - e. PMP-131 and –141 mix sludge in Digester No. 6
  - 3. Local control:
    - a. The sludge circulation pump is provided with a local control station (LCS) with the following controls:
      - 1) Local-Off-Remote (L-O-R) selector switch
      - 2) Start push button
      - 3) Stop push button
    - b. With the LOR in LOCAL, the sludge circulation pump is controlled locally by the start and stop push buttons.
    - c. With the LOR switch in REMOTE, the sludge circulation pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
    - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the sludge circulation pump starts.
    - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the sludge circulation pump is controlled via the PLC/SCADA.
  - 4. Hardwired control:
    - a. Hardwired interlocks/Overload Programmed Interlocks:
      - 1) The sludge circulation pump is stopped and prohibited from starting if one of the following occurs:
        - a) Pump motor winding high temperature.
        - b) Pump motor overload.
      - 2) Once the condition has cleared, the pump will restart.
  - 5. PLC control:
    - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.



- b. When the sludge circulation pump is in READY status, the pump can be controlled through the PLC.
  - 6. PCS/LOI/HMI control:
    - a. When the sludge circulation pump is in READY status, the pump can be controlled by the start-stop buttons on the digester sludge circulation graphic display screen.
  - 7. SCADA indicators and alarms:
    - a. Refer to PIDs.
- B. Loop FLA-151 and FLA-152 – Digester Gas Flares
  - 1. References:
    - a. Drawing 10N03
  - 2. Abstract:
    - a. Digester gas flares are used for burning excess digester gas. Excess gas that is not utilized in the combined heat and power (CHP facility) is flared using two waste gas burners.
    - b. The waste gas burners include propane-fueled pilot ignition systems.
    - c. The waste gas burners operate with one unit in service during normal conditions. The units are set at different pressures such that the second burner is brought online when the target gas pressure is reached.
  - 3. Control:
    - a. The flare system is controlled locally via the vendor control panel
    - b. Refer to PIDs for PLC I/O and HMI indication.
- C. FOG SYSTEM:
  - 1. References:
    - a. Drawings 20N01 through 21N04
    - b. Mechanical Drawings 20M01 through 20M04
  - 2. General Description:
    - a. The FOG (Fats, Oils, and Grease) Receiving system includes an offloading system with a valve, rock trap/macerator, and pump; a FOG tank with a tank mixing/heating system and level monitoring system; a digester feed pump; and control valves used to automate the FOG SYSTEM.
    - b. Local controls for each equipment and control valve are described in their respective control strategies. This section includes the control strategy for remote automatic mode for all of the FOG equipment and control valves.
    - c. To operate in remote automatic mode, all equipment and control valves within the FOG System must be set to remote automatic mode.
  - 3. General Description of AUTO Operation:
    - a. FOG Offloading sequence:
      - 1) FOG Offloading Control Panel with card reader and light indicators, which is designed for the FOG hauler's use, is provided near the offloading equipment adjacent to the FOG fill connection for FOG offloading operation. Prior to offloading, the level in the FOG Tank is checked to ensure there is available storage volume in the FOG Tank to accommodate the hauler's tanker volume, which is read from the hauler's ID card.
      - 2) The Truck Offloading Pump is used to pump the FOG truck contents through the Rock Trap / Macerator and into the FOG Tank. The Rock Trap / Macerator removes large debris and grinds other material to help prevent downstream clogs.



- 3) High-High Level from FOG tank level instrument LIT-211 shall close FOG off-loading control valve FCV-211 and initiate the FOG macerator shutdown protocols.
- 4) A red light (in use) at the FOG Offloading Control Panel will indicate that the FOG Tank is unavailable for FOG delivery. A green light (ready) will indicate to incoming FOG Haulers that the FOG Tank is available for delivery. A flashing yellow light (fill) at the FOG Offloading Control Panel will indicate to the FOG Hauler that they cannot disconnect their fill hose.
- b. FOG Mixing/Heating sequence:
  - 1) A mixing/heating sequence is automatically initiated when the FOG tank WSE level reaches and operator adjustable target low level setpoint. When the FOG tank WSE level drops below the operator adjustable target low level setpoint, the mixing/heating sequence is automatically stopped.
- c. FOG Digester Feed sequence:
  - 1) Operator will select the target flow rate and the target feed time per digester prior to starting the Digester Feed sequence. The Digester Feed sequence will pump the FOG Tank contents to the digesters until an operator low level setpoint level in the FOG tank is reached.
4. Local Controls and Instrumentation:
  - a. See each specific equipment and control valve control strategy.
5. AUTO Controls and Instrumentation:
  - a. FOG SYSTEM operation is controlled by the PLC and the Offloading, Mixing/Heating, and Digester Feed sequences can be initiated at the FOG Offloading Control Panel or at the SCADA/HMI
  - b. FOG Offloading Sequence:
    - 1) To initiate the FOG Offloading Sequence, the FOG Hauler scans a valid access card.
    - 2) Prior to offloading, the FOG Tank level transmitter (LIT-211) is used to check if there is available storage volume in the FOG Tank to accommodate the hauler's tanker volume, which is linked to the hauler's ID card:
      - a) If there is enough volume in the FOG tank to accommodate the hauler's tanker volume:
        - (1) The FOG hauler connects their truck hose to the FOG Receiving Facility fill connection and presses the "START OFFLOADING SEQUENCE" button at the FOG Offloading Control Panel.
          - (a) The "START OFFLOADING SEQUENCE" may also be initiated by operations personnel via SCADA.
        - (2) The green light (ready) at the FOG Offloading Control Panel shall turn off and the red light (in use) at the FOG Offloading Control Panel shall turn on.
        - (3) The FOG tank level measurement device shall measure the liquid level in the FOG Tank and the level reading shall be recorded to the PLC as the "PRE-DELIVERY LEVEL" for that date and time.
        - (4) The FOG Offloading Control Valve shall open.
        - (5) A yellow light (fill) at the FOG Offloading Control Panel shall begin flashing to indicate to the FOG Hauler that the hose



- should not be disconnected. The red light shall remain lit while the yellow light is flashing.
- (6) The FOG Rock Trap / Macerator shall start.
  - (7) After finishing offloading FOG, the FOG offloading pump shall press the "STOP OFFLOADING SEQUENCE" button at the FOG Offloading Control Panel.
  - (8) The FOG Offloading Control Valve shall close.
  - (9) The flashing yellow light (fill) at the FOG Offloading Control Panel shall turn off to indicate to the FOG Hauler that their fill hose can be disconnected. The red light (in use) shall remain lit.
  - (10) The FOG tank level measurement device shall measure the liquid level in the FOG Tank and the level reading shall be recorded to the PLC as the "POST-DELIVERY LEVEL" for that date and time.
  - (11) The PLC shall calculate the "FOG VOLUME DELIVERED" using the difference between "PRE-DELIVERY LEVEL" and "POST-DELIVERY LEVEL." The calculated "FOG VOLUME DELIVERED" shall be recorded to the PLC for that date, time, and FOG Hauler card ID.
- b) If there is not enough volume in the FOG tank to accommodate the hauler's tanker volume:
- (1) The green light (ready) at the FOG Offloading Control Panel shall turn off and the red light (in use) at the FOG Offloading Control Panel shall begin flashing to indicate the driver shall call Operations staff.
  - (2) The FOG Offloading Control Valve shall remain closed.
- 3) Mixing/Heating Sequence:
- a) The FOG Mixing Pump shall start when the tank level reaches an operator adjustable low level setpoint.
  - b) The FOG Hot Water Pump shall start after the FOG Mixing Pump has been operating for an operator adjustable period of time.
  - c) The 3-way temperature control valve blends hot water supply with hot water return water from the heat exchanger to control the temperature of the FOG entering the heat exchanger at an operator adjustable setpoint. The temperature of the FOG at the inlet of the heat exchanger is measured by temperature transmitter TIT-212.
  - d) If the temperature of the hot water supply to the heat exchanger reaches an operator adjustable setpoint, the position of the 3-way temperature control valve shall be moved to full bypass to exclude the addition of hot water from the main hot water loop. When the temperature decreases to a value below the HIGH setpoint, automatic control resumes.
  - e) The FOG Mixing Pump and FOG Hot Water Pump shall operate until the FOG temperature at the inlet of the FOG heat exchanger reaches an operator-adjustable setpoint.
  - f) While the level in the FOG Tank remains above an operator adjustable low level setpoint, the FOG Mixing Pump and FOG Hot Water Pump shall intermittently operate based on an operator adjustable setpoint in minutes per hour.

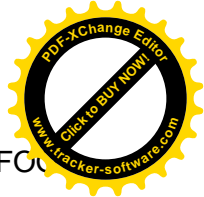






- 2) Start push button
      - 3) Stop push button
      - 4) Speed pot
    - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
    - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
    - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
    - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
  4. PMP-211 Hardwired control:
    - a. Hardwired interlocks/Overload Programmed Interlocks:
      - 1) The sludge circulation pump is stopped and prohibited from starting if one of the following occurs:
        - a) Pump motor winding high temperature.
        - b) Pump motor overload.
        - c) Pump high discharge pressure (via SCADA)
      - 2) Once the condition has cleared, the pump will restart.
  5. PMP-211 PLC control:
    - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
    - b. When the pump is in READY status, the pump can be controlled through the PLC.
  6. PMP-211 PCS/LOI/HMI control:
    - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
  7. PMP-211 SCADA indicators and alarms:
    - a. Refer to PIDs.
  8. FCV-211 Local control:
    - a. The FOG offloading control valve is provided with the following controls
      - 1) Local-Off-Remote (L-O-R) selector switch
      - 2) Open-Stop-Close (OSC) selector switch
    - b. With the LOR in LOCAL, the offloading control valve is controlled locally by the OSC selector switch.
    - c. With the LOR switch in REMOTE offloading control valve is controlled via the PLC/SCADA.
  9. FCV-211 SCADA indicators and alarms:
    - a. Refer to PIDs.
- E. Loop PMP-212– FOG TANK FEED, CIRCULATION, AND HEATING SYSTEM:
1. References:
    - a. Drawing 20N02
  2. Abstract
    - a. One fats, oils, and grease (FOG) Tank is equipped with a tank level monitoring system and a FOG tank mixing system. The FOG Mix Pump (PMP-212) is used in the operation of the FOG Receiving Facility as described in the FOG SYSTEM control strategy.
    - b. A FOG Tank Mix Pump (PMP-212) is provided to mix the FOG inside the tank. The pump shall start and stop based on operator-adjustable FOG level setpoints.





- c. A heat exchanger (HEX-211) is provided between the Mix Pump and FOG Tank.
- d. Temperature transmitter TIT-212 is provided upstream of the heat exchanger to measure the FOG temperature.
- e. The FOG level in the FOG Tank is measured by a level transmitter (LIT-211). An alarm shall activate when the FOG level reaches an operator-adjustable "High Level" setpoint. This alarm is used to inform plant staff the FOG level in the FOG tank is near the emergency overflow pipe.
- 3. Local control:
  - a. The pump is provided with a local control station (LCS) with the following controls:
    - 1) Local-Off-Remote (L-O-R) selector switch
    - 2) Start push button
    - 3) Stop push button
  - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
  - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
  - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
  - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
- 4. Hardwired control:
  - a. Hardwired interlocks/Overload Programmed Interlocks:
    - 1) The pump is stopped and prohibited from starting if one of the following occurs:
      - a) Pump motor winding high temperature.
      - b) Pump motor overload.
    - 2) Once the condition has cleared, the pump will restart.
- 5. PLC control:
  - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
  - b. When the pump is in READY status, the pump can be controlled through the PLC.
- 6. PCS/LOI/HMI control:
  - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
- 7. SCADA indicators and alarms:
  - a. Refer to PIDs.

F. Loop PMP-213– DIGESTER FOG FEED VALVE AND PUMP

- 1. References:
  - a. 20N03
- 2. Abstract:
  - a. The Digester FOG Feed Pump (PMP-213) and two automated Digester FOG Feed Valves (FCV-212 and FCV-213) are used to empty the FOG Tank and deliver FOG to Digester Nos. 5 and 6.
  - b. The Digester FOG Feed Pump shall start and stop based on operator-adjustable FOG level setpoints inside the tank. The Digester FOG Feed Pump is equipped with a variable frequency drive (VFD) to allow the pump to operate at an operator-adjustable flow rate.



- c. A flowmeter (FIT-211) is provided on the discharge of the Digester FOG Feed Pump to measure the FOG flow.
  - d. The Digester FOG Feed Valves operate as shown in the FOG SYSTEM description.
- 3. Local control:
  - a. The pump is provided with a local control station (LCS) with the following controls:
    - 1) Local-Off-Remote (L-O-R) selector switch
    - 2) Start push button
    - 3) Stop push button
    - 4) Speed pot
  - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
  - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
  - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
  - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
- 4. Hardwired control:
  - a. Hardwired interlocks/Overload Programmed Interlocks:
    - 1) The sludge circulation pump is stopped and prohibited from starting if one of the following occurs:
      - a) Pump motor winding high temperature.
      - b) Pump motor overload.
      - c) Pump high discharge pressure (via SCADA).
    - 2) Once the condition has cleared, the pump will restart.
- 5. PLC control:
  - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
  - b. When the pump is in READY status, the pump can be controlled through the PLC.
- 6. PCS/LOI/HMI control:
  - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
- 7. SCADA indicators and alarms:
  - a. Refer to PIDs.
- 8. FCV-212, FCV-213 Local control:
  - a. The Digester FOG feed control valve is provided with the following controls
    - 1) Local-Off-Remote (L-O-R) selector switch
    - 2) Open-Stop-Close (OSC) selector switch
  - b. With the LOR in LOCAL, the valve is controlled locally by the OSC selector switch.
  - c. With the LOR switch in REMOTE valve is controlled via the PLC/SCADA.
- 9. FCV-212, FCV-213 SCADA indicators and alarms:
  - a. Refer to PIDs.



- G. Loop PMP-214, PMP-215 – FOG RECIRCULATION HOT WATER SYSTEM:
1. Reference: Drawing 20N04
  2. Abstract:
    - a. FOG Recirculation Line Hot Water Pump (PMP-214 and -215) are used for pumping the hot water to the heat exchanger to heat the FOG. The FOG recirculation hot water system pulls water from the primary hot water loop.
    - b. The hot water system includes two pumps, one duty and one standby.
    - c. One three-way valve (FCV-214) shall be designated to provide the heating load requirement by diluting the right amount of hot fluid with the colder HWR (hot water return) from the FOG heat exchanger (HEX-211).
    - d. Heat exchanger HEX-211 is provided downstream of the FOG Hot Water Pumps.
    - e. Temperature transmitter TIT-213 is provided upstream of the heat exchanger to measure the HWS temperature.
    - f. Temperature transmitter TIT-214 is provided downstream of the heat exchanger to measure the HWR temperature.
  3. Local control:
    - a. The pump is provided with a local control station (LCS) with the following controls:
      - 1) Local-Off-Remote (L-O-R) selector switch
      - 2) Start push button
      - 3) Stop push button
    - b. With the LOR in LOCAL, the pump is controlled locally by the start and stop push buttons.
    - c. With the LOR switch in REMOTE, the pump is controlled by the HAND-OFF-SCADA selector switch at the MCC.
    - d. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in HAND, the pump starts.
    - e. With the LOR switch in REMOTE and the HAND-OFF-SCADA selector switch in SCADA, the pump is controlled via the PLC/SCADA.
  4. Hardwired control:
    - a. Hardwired interlocks/Overload Programmed Interlocks:
      - 1) The pump is stopped and prohibited from starting if one of the following occurs:
        - a) Pump motor winding high temperature.
        - b) Pump motor overload.
      - 2) Once the condition has cleared, the pump will restart.
  5. PLC control:
    - a. READY status indicates that REMOTE and SCADA mode is selected, supply power normal and hardwire interlocks satisfied.
    - b. When the pump is in READY status, the pump can be controlled through the PLC.
  6. PCS/LOI/HMI control:
    - a. When the pump is in READY status, the pump can be controlled by the start-stop buttons on the graphic display screen.
  7. SCADA indicators and alarms:
    - a. Refer to PIDs.



#### **ART 4 REPAIR/RESTORATION (NOT USED)**

##### **4.01 RE-INSTALLATION (NOT USED)**

##### **4.02 FIELD QUALITY CONTROL (NOT USED)**

##### **4.03 ADJUSTING (NOT USED)**

##### **4.04 CLEANING (NOT USED)**

##### **4.05 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### **4.06 PROTECTION (NOT USED)**

##### **4.07 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 17208

### LEVEL MEASUREMENT: RADAR PULSE TIME OF FLIGHT (PTOF)

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Non-contact radar (PTOF) level instruments.
- B. Provide all instruments identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. PTOF: Pulse Time of Flight.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Emerson, Rosemount 5400.
  - 2. Endress+Hauser, Micropilot M.
  - 3. Siemens/Milltronics, LR250.
  - 4. Ohmart Vega, VegaPuls.
  - 5. Ametek Drexelbrook, DR7000 Series.

## **2.02 MANUFACTURED UNITS**

- A. Pulse Time of Flight:
  - 1. General:
    - a. Instrument emits radar pulses via a transmitter, with a frequency range of 6.3 GHz to 26 GHz.
    - b. The pulses reflect from the surface being measured and are received back at the instrument via a sensor.
    - c. The instrument measures the pulse travel time between the transmitter, surface, and receiver to calculate the level.
    - d. Safety:
      - 1) Shall not generate frequency waves with power levels hazardous to humans.
  - 2. Performance requirements:
    - a. Accuracy: Level:
      - 1) 0.25-inch.
  - 3. Element:
    - a. Level element must conform to the process material compatibility as indicated on the Instrument Data Sheets or the Instrument Index.



- b. Connections:
  - 1) Process: The antenna design shall be suitable for mounting in a nozzle as indicated on the Instrument Data Sheets or the Instrument Index.
  - 2) The design shall be such that product condensation on the antenna shall not affect the performance of the gauge. It shall be possible to choose between either parabolic-, cone-, rod-shaped antennas.
- 4. Transmitter:
  - a. Microprocessor-based signal converter/transmitter.
  - b. Power supply:
    - 1) 24 VDC - 2-wire loop powered.
    - 2) Power consumption: 15 VA maximum.
  - c. Outputs:
    - 1) Isolated 4-20 mA DC with HART communication protocol.
  - d. Backlit digital display for level or volume.
  - e. Self-diagnostics and automatic data checking.
  - f. Signal integrity:
    - 1) Immune to radio frequency and electromagnetic interference with field strength of 15 volts/meter or less over a frequency range of 50 Hz to 460 MHz.
    - 2) Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
  - g. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
    - 1) Indication: Local - 5-digit display.
  - h. Enclosure rating: NEMA Type 4X.
  - i. Electrical connection: 1/2-inch male NPT.

### **2.03 ACCESSORIES**

- A. Software: Provide Windows based PC software for configuration and echo mapping.
- B. Provide sun shield for outdoor installations.
- C. Provide a remote loop indicator/display in accordance with Section 17710, and as show on the drawings. Loop indicator/display shall be able to accept a 4-20 mA signal and provide an isolated 4-20 mA signal to the PLC.

### **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each level transmitter at a facility that is traceable to NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.



## **ART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
  - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.
- C. Furnish 2 hours of Owner training.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.





### 3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be indicated on the Drawings, specified in the Specifications or both.
  2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system.

END OF SECTION





## SECTION 17302

### FLOW MEASUREMENT: MAGNETIC FLOWMETERS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Full-body magnetic flowmeters.
- B. Provide all instruments identified in the Contract Drawings.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. International Organization for Standardization (ISO):
  - 1. 9000 - Quality management systems -- Fundamentals and vocabulary.
  - 2. 17025 - General requirements for the competence of testing and calibration laboratories.
- C. National Institute of Standards and Technology (NIST).
- D. NSF International (NSF).

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Include sizing information from the manufacturer that includes:
  - 1. Chart of the measurement error from zero to maximum measured volumetric flow range indicated in data sheets.
  - 2. Indication of all input parameters and their values used in the calculations.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.



2. Physical conditions:
  - a. Installation and mounting requirements.
  - b. Location within the process.
  - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  1. Endress+Hauser: Promag 53.
  2. Rosemount – 8700.
  3. Krohne - IFC.
  4. Toshiba - LF

## **2.02 MANUFACTURED UNITS**

- A. Magnetic flowmeter:
  1. General:
    - a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
    - b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
    - c. Include for each magnetic flow metering system:
      - 1) A metering tube with electrodes (sensor).
      - 2) Signal cable.
      - 3) Transmitter integral or remote as indicated on the Drawings.



- 4) Flowmeter grounding rings.
2. Performance requirements:
  - a. Accuracy:
    - 1) 0.25 percent of flow rate from 10 to 100 percent of full-scale for velocities ranging between 1.9 to 10 feet per second.
  - b. Repeatability:
    - 1) 0.25 percent of rate.
3. Element:
  - a. Metering tube:
    - 1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
    - 2) Liner material in conformance with:
      - a) Manufacturer's recommendations for the intended service.
      - b) NSF certified for all drinking water applications.
    - 3) Electrodes type and material in conformance with:
      - a) Manufacturer's recommendations for the intended service.
      - b) Utilize a minimum of 2, self-cleaning electrodes.
    - 4) Meter terminal housing NEMA Type 4X, unless installed in locations such as vaults that will experience submergence. In those applications NEMA 6P is required.
      - a) Unless specifically noted otherwise in the instrument data sheets.
    - 5) Meter coating consisting of epoxy painted finish.
    - 6) Components:
      - a) 2 grounding rings:
        - (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
        - (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.
  4. Transmitter:
    - a. Power supply:
      - 1) As indicated in the data sheets.
      - 2) Power consumption: 60 VA maximum.
    - b. Outputs:
      - 1) As noted in the instrument data sheets.
      - 2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
    - c. Microprocessor-based signal converter/transmitter.
    - d. Utilize DC pulse technique to drive flux-producing coils.
    - e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
    - f. Operator keypad interface.
    - g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
    - h. Integral low flow cut-off zero return.
    - i. Programmable parameters including:
      - 1) Meter size.
      - 2) Full-scale flow rate.
      - 3) Magnetic field frequency.
      - 4) Time constant.
    - j. Data retention for a minimum of 5 years without auxiliary main or battery power.



- k. Self-diagnostics and automatic data checking.
- l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
- m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

## **2.03 ACCESSORIES**

- A. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.
- B. Provide sunshades for all transmitters located outdoors.
- C. Provide galvanic isolation gaskets, nylon/Teflon™ flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each flow metering system at a facility that is traceable to the NIST. ISO-17025 accredited test facility with certified accuracy traceable to NIST.
- C. Evidence of accreditation shall originate from a national verification agency such as A2LA.
- D. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
  - 1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
  - 2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
  - 3. Manufacturer shall archive all calibration reports for future reference.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. For instruments located outdoors or where instrument elements and transmitters are separated by conduit located outside the building envelope, provide surge protection devices at the transmitters.



### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection.

### **3.05 ADJUSTING**

- A. Field Verification:
  - 1. Verify factory calibration of all instruments in accordance with the manufacturer's instructions.
  - 2. The transmitter and sensor to include a method to verify flow meter performance to the original manufacturer specifications.
  - 3. Verification should be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.
  - 4. The verification report should be compliant to common quality systems such as ISO 9000 to prove reliability of the meter specified accuracy.
  - 5. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES**

- A. Instrument Data Sheets included in this Section.
- B. The provided information does not necessarily include all required instruments.
- C. Provide all instruments identified in the Contract Documents:
  - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.
  - 2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION







## SECTION 17401

### PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Diaphragm seals.
  - 2. Annular seals.
- B. Provide all seals identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Manufacturer's installation instructions.
    - b. Seal type.
    - c. Body materials.
    - d. Diaphragm material.
    - e. Fill fluid type.
    - f. Seal size.
    - g. Options.
    - h. Process connection.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.



- c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide spare annular seal for every size indicated in the project.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Diaphragm seals:
  - 1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
    - a. Ashcroft:
      - 1) Flushing connection: Type 741.
      - 2) Without flushing connection: Type 740.
    - b. Mansfield and Green:
      - 1) Flushing connection: Type SGT.
      - 2) Without flushing connection: Type SBT.
    - c. Wika, Type L990.40.
    - d. Emerson, Rosemount.
  - 2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
    - a. Ashcroft:
      - 1) Flushing connection: Type 201.
      - 2) Without flushing connection: Type 200.
      - 3) Saddle mount: Type 205.



- b. Mansfield and Green:
  - 1) Flushing connection: Type SG.
  - 2) Without flushing connection: Type SB.
- c. Wika:
  - 1) Type L990.10.

- B. Annular seals:
  - 1. One of the following or equal:
    - a. Ashcroft, Wafer Isolation Ring.
    - b. Onyx Valve.

## 2.02 MANUFACTURED UNITS

- A. Diaphragm seals:
  - 1. General:
    - a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
  - 2. Requirements:
    - a. Seal type:
      - 1) Metallic diaphragm: Welded to upper housing.
      - 2) Elastomer diaphragm: Bonded to upper housing.
    - b. Process connection: 1 inch NPT.
    - c. Instrument connection: 1/2 inch NPT.
    - d. Material Construction: Type 316 Stainless Steel.
    - e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
    - f. Flush port plug: Same material of construction as diaphragm lower housing.
    - g. Provide fill/bleed connection.
    - h. Mounting: As indicated in the Contract Documents.
    - i. Provide Type 316 stainless steel armored capillary for all remote installations.
    - j. Nuts and bolts: Type 316 stainless steel.
    - k. Materials of construction:
      - 1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
        - a) Diaphragm: Type 316 stainless steel.
        - b) Lower housing: Type 316 stainless steel.
        - c) Upper housing: Manufacturer's standard.
        - d) Fill fluid: Silicone oil.
      - 2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
        - a) Diaphragm: Type 316 stainless steel.
        - b) Lower housing: Type 316 stainless steel.
        - c) Upper housing: Manufacturer's standard.
        - d) Fill fluid: Silicone oil.
- B. Annular seals:
  - 1. General:
    - a. Inside diameter of annular seal shall provide uninterrupted flow:
      - 1) There shall be no dead ends or crevices.



- 2) Process flow shall be sufficient to make the annular seal self-cleaning.
  - b. The pressure sensing flexible cylinder shall measure pressure around the full inside circumference of the pipeline.
2. Requirements:
  - a. Pressure rating: Equivalent to the ANSI flanges.
  - b. Materials of construction:
    - 1) Inner flexible cylinder: Manufacturer's standard.
    - 2) Body:
      - a) Carbon Steel with epoxy coating.
    - 3) Assembly flanges: To match adjacent piping.
    - 4) Fill fluid: Silicone oil.
  - c. Instrument connection: 1/2 inch NPT.

### **2.03 ACCESSORIES (NOT USED)**

### **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Do not use Teflon thread seal tape on pressure instruments with silicone oil fill fluid.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING (NOT USED)**

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 17402

### PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Valve manifolds and instrument valves.
- B. Provide all valves identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Valve type.
    - b. Body material.
    - c. Size.
    - d. Options.
  - 2. Shop drawings:
    - a. Mounting details for all manifold valves.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.



- C. Notify the Engineer if any installation condition does not meet the valve manufacturer's recommendations or specifications.
- D. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

#### **1.07 PROJECT OR SITE CONDITIONS**

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. Provide valves suitable for the installed site conditions including, but not limited to, material compatibility, process, and ambient temperatures.

#### **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

- A. Valve manifold:
  - 1. One of the following or equal:
    - a. Anderson Greenwood.
    - b. Hex Valve.
    - c. Noshok.
    - d. Emerson, Rosemount.
- B. Block and bleed valve:
  - 1. One of the following or equal:
    - a. Anderson Greenwood.
    - b. Hex Valve.





- C. Gauge valve:
  - 1. One of the following or equal:
    - a. Anderson Greenwood.
    - b. Hex Valve.
- D. Level sensor isolation valve:
  - 1. One of the following or equal:
    - a. Indu-Tech, Level Sensor Isolation Valve.
    - b. DeZURIK, Level Sensor Isolation Valve.
    - c. Tyco, Rovalve Isolation Knife Gate Valve.

## 2.02 MANUFACTURED UNITS

- A. Valve manifolds:
  - 1. General:
    - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
    - b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
  - 2. Requirements:
    - a. Bonnet lock pin to prevent accidental loosening.
    - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
    - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
    - e. Manifold valves shall allow for direct or remote instrument mounting.
    - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
    - g. Materials of construction:
      - 1) Body material: Type 316 stainless steel.
      - 2) O-Ring: Teflon.
    - h. 2-Valve manifolds:
      - 1) 1 isolation valve and 1 drain/vent and calibration valve.
    - i. 3-Valve manifolds:
      - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
      - 2) Plugged vent connections used for vent/drain or calibration.
    - j. Blowdown 5-valve manifold:
      - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
    - k. Metering 5-valve manifold:
      - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
- B. Block and bleed valves:
  - 1. General:
    - a. Valve shall provide process isolation and venting/draining capabilities.
    - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
    - d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.



2. Requirements:
  - a. Materials of construction:
    - 1) Body material: Type 316 stainless steel.
    - 2) O-Ring: Teflon.
- C. Gauge valves:
  1. General:
    - a. Valve shall provide process isolation from pressure instrument.
    - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
  2. Requirements:
    - a. Materials of construction:
      - 1) Body material: Type 316 stainless steel.
      - 2) O-Ring: Teflon.
- D. Level sensor isolation valves:
  1. General:
    - a. Valve shall provide process isolation from level diaphragm.
    - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
    - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
  2. Requirements:
    - a. Materials of construction:
      - 1) Body material: Type 316 stainless steel.
      - 2) Flange diameter size: 3 inches.

## **2.03 ACCESSORIES**

- A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
- B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION**

- A. Examine the installation location and verify it will work properly when installed.
  1. Notify the Engineer promptly if any installation condition does not meet the manufacturer's recommendations or specifications.

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all valves to the Engineer before commissioning.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 17403

### PRESSURE/VACUUM MEASUREMENT: SWITCHES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Pressure/vacuum switches.
- B. Provide all instruments specified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Electronic type pressure switch: One of the following or equal:
  - 1. Ashcroft, B Series Type 400.
  - 2. United Electric, 400 Series.

## **2.02 MANUFACTURED UNITS**

- A. Mechanical type pressure switches:
  - 1. General:
    - a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
  - 2. Performance requirements:
    - a. Accuracy:
      - 1) Within 1.0 percent of range.
    - b. Repeatability:
      - 1) Within 1.0 percent of range.
  - 3. Element:
    - a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
    - b. Overpressure:
      - 1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      - 2) Minimum 400 percent of nominal range without leakage or rupture.
    - c. Sensing element shall not require ambient temperature compensation.
    - d. Wetted materials: Stainless steel



- e. Setpoint:
    - 1) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
  - f. Adjustable deadband.
  - g. Switch elements:
    - 1) Snap acting.
    - 2) Rated at 5 A, 125/250 VAC.
  - h. Enclosure: Epoxy coated:
    - 1) NEMA Type 4.
    - 2) NEMA Type 4X.
    - 3) NEMA Type 7.
  - i. Switch mounting:
    - 1) Process connection: 1/2-inch NPT.
  - 4. Components:
    - a. Provide all necessary hardware for pressure switch mounting.
- B. Electronic indicating type pressure switches:
- 1. General:
    - a. Pressure switch shall utilize ceramic or polysilicon thin film pressure transducer.
  - 2. Performance requirements:
    - a. Pressure range:
      - 1) As specified in data sheets.
    - b. Accuracy:
      - 1) Within 1.0 percent of range.
    - c. Repeatability:
      - 1) Within 1.0 percent of range.
  - 3. Element:
    - a. Type: Ceramic or polysilicon thin film.
    - b. Overpressure:
      - 1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      - 2) Minimum 400 percent of nominal range without leakage or rupture.
    - c. Sensing element shall not require ambient temperature compensation.
    - d. Wetted materials: Stainless steel.
  - 4. Transmitter:
    - a. Setpoint:
      - 1) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
    - b. Adjustable deadband.
    - c. Switch elements:
      - 1) Snap acting.
    - d. Enclosure: Epoxy-coated.
      - 1) NEMA Type 4X.
    - e. Local display:
      - 1) 4-digit LCD or LED.
      - 2) Scaled in engineering units.
    - f. Switch mounting:
      - 1) Process connection: 1/2-inch NPT.



- g. Power supply:
  - 1) 120 VAC.
  - 2) Power consumption: 3 VA maximum.
- h. Outputs:
  - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
- i. Relay outputs:
  - 1) Form C contacts: 2.
- j. Rated 5 amps at 120 VAC.
- k. Components:
  - 1) Provide all necessary hardware for pressure switch mounting.
  - 2) Provide sun shield for outdoor installations.

## **2.03 ACCESSORIES**

- A. Pulsation dampeners and snubbers:
  - 1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
  - 2. Materials: Stainless steel.
  - 3. Mount pulsation dampener or snubber integrally to the pressure switch.
  - 4. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in data sheets or as indicated on the Drawings and as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
  - 1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.
- C. Furnish block and bleed valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.
- D. Furnish gauge valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.
- E. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
  - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.





## **PART 3 EXECUTION**

### **3.01 EXAMINATION (NOT USED)**

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
  - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.09 SCHEDULES**

- A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
  - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.
  - 2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION





## SECTION 17404

### PRESSURE/VACUUM MEASUREMENT: GAUGES

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Pressure/vacuum gauges.
- B. Provide all instruments specified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. American Society of Mechanical Engineers (ASME):
  - 1. B40.100 - Pressure Gauges and Gauge Attachments.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
  - 1. Product data:
    - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.



- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Ashcroft:
  - 2. Wika.
  - 3. Ametek U.S. Gauge.

## **2.02 MANUFACTURED UNITS**

- A. General:
  - 1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.
- B. Performance requirements:
  - 1. Pressure range:
    - a. As specified in the Contract Documents.
  - 2. Accuracy:
    - a. Grade 2A, as defined by ASME B40.100.
    - b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
    - c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
  - 3. Element:
    - a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
    - b. Socket tips for bellows and Bourdon® tube:
      - 1) Materials: Type 316 stainless steel.



- c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
- d. Wetted materials: Type 316 stainless steel.
- 4. Dial gauge:
  - a. Dial size: 4-1/2 inches.
  - b. Dial case material:
    - 1) Maximum pressure less than 10 pounds per square inch:
      - a) Phenolic.
    - 2) Maximum pressure greater than or equal to 10 pounds per square inch:
      - a) 316 Stainless steel.
  - c. Provide safety gauge with safety blow out through the back or top of the unit.
  - d. Dial face: Gasketed shatterproof glass or polycarbonate.
  - e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
  - f. Provide gauge locks where possible.
  - g. Hermetically sealed.
  - h. Connection and mounting:
    - 1) Direct mounted and suitable for outdoor installation.
    - 2) 1/2-inch NPT.
    - 3) Connection material: 316 Stainless steel.
  - i. Pointer: Externally adjustable.

## **2.03 ACCESSORIES**

- A. Pulsation dampeners and snubbers:
  - 1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
  - 2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
  - 3. Materials: Type 316 stainless steel.
  - 4. Mount pulsation dampener or snubber integrally to the pressure gauge.
  - 5. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
  - 1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- C. Provide means for gauge isolation as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves:
  - 1. Mount valve manifold integrally to the gauge.
  - 2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



- B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**

#### **3.02 PREPARATION (NOT USED)**

#### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

#### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.05 ADJUSTING**

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
  - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

#### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



### 3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be indicated on the Drawings, specified in the Specifications or both.
  2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION







## SECTION 17602

### TEMPERATURE MEASUREMENT: TEMPERATURE GAUGE

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Temperature gauges.
- B. Provide all instruments identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.



## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. Bimetallic type temperature gauge:
  - 1. Manufactures: One of the following or equal:
    - a. Ashcroft, Type EI.
    - b. Weiss Instruments, Series BM.
    - c. Noshok, 300 Series.

## **2.02 MANUFACTURED UNITS**

- A. Bimetallic type temperature gauges:
  - 1. General:
    - a. Temperature gauges shall consist of a bimetallic temperature sensor with a dial-type temperature gauge.
  - 2. Performance requirements:
    - a. Temperature range:
      - 1) As indicated in the Contract Documents.
    - b. Accuracy:
      - 1) Within 1.0 percent of range.
  - 3. Element:
    - a. Type: Bimetallic.
    - b. Stem material: 316 Stainless steel.
    - c. Temperature gauge sensor shall be tamperproof, hermetically sealed, and silicon dampened.
    - d. Process connection: 1/2-inch NPT.



4. Dial gauge:
  - a. Dial size: 3 inches.
  - b. Dial case material: 316 Stainless steel.
  - c. Dial face: Gasketed shatterproof glass.
  - d. Orientation: Straight or angled as required to provide most convenient direct viewing.
  - e. Mounting: Direct mounted and suitable for outdoor installation.
  - f. External adjustable recalibration screw.

## **2.03 ACCESSORIES**

- A. Thermowell:
  1. Unless otherwise noted, provide Thermowell with each temperature gauge.
  2. Process connection: As indicated in the contract documents.
  3. Thermowell material: Material compatible with the service fluid identified and recommended by the manufacturer for the process condition.
  4. Stem style: Straight or tapered.
  5. Immersion depth:
    - a. Minimum 3 inches or 10 times the diameter of the sensor protection tube or Thermowell, whichever is larger.
- B. Provide sunshades for outdoor installations.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
  1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

# **PART 3 EXECUTION**

## **3.01 EXAMINATION**

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
  1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



#### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.05 ADJUSTING**

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

#### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.09 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 17604

### TEMPERATURE MEASUREMENT: RTD

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. RTD temperature instruments.
- B. Provide all instruments identified in the Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. RTD - Resistance temperature detector.

##### 1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

##### 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
  - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
  - 2. Physical conditions:
    - a. Installation and mounting requirements.
    - b. Location within the process.
    - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.



- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

## **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.08 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.09 MAINTENANCE**

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Process Measurement:
    - a. Emerson, Rosemount 3144P transmitter with Series 214C sensor.
    - b. Siemens, SITRANS T.
    - c. Foxboro, Model RTT20.

## **2.02 MANUFACTURED UNITS**

- A. Process measurement:
  - 1. General:
    - a. Temperature measuring instrument shall include an RTD temperature element, transmitter, and thermowell.
  - 2. Performance requirements:
    - a. Accuracy:
      - 1) Within 0.25 percent of calibrated span.
    - b. Repeatability:
      - 1) 0.25 percent of full scale.
    - c. Sensor lead wire compensation: Maximum zero shift of 0.2 percent of the temperature range.
  - 3. Element:
    - a. 100-Ohm platinum thin film resistance temperature detector (RTD).
    - b. 3-wire.



- c. Hermetically-sealed, and enclosed in Type 316 stainless steel outer sheath.
- d. Single element temperature sensor shall be spring-loaded.
- 4. Transmitter:
  - a. Microprocessor based.
  - b. Compatible with 3-wire and 4-wire RTD inputs:
  - c. Local display:
    - 1) 5-digit LCD.
    - 2) Scaled in engineering units.
  - d. Power supply:
    - 1) 24 VDC - loop powered.
  - e. Outputs:
    - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
  - f. Transmitter enclosure:
    - 1) NEMA Type 7.
  - g. Transmitter mounting:
    - 1) As specified on the Instrument Data Sheets or Instrument Index.
    - 2) Connection to thermowell: 1/2-inch NPT.
    - 3) Provide all necessary hardware for transmitter mounting.

## **2.03 ACCESSORIES**

- A. Thermowell:
  - 1. Unless otherwise noted, provide a thermowell with each RTD.
  - 2. Process connection: As identified on instrument data sheet.
  - 3. Thermowell material: Type 316L stainless steel
  - 4. Stem style: As identified on instrument data sheet.
  - 5. Immersion depth:
    - a. Minimum 3 inches or 10 times the diameter of the thermowell, whichever is larger.
    - b. Where pipe diameter is inadequate for appropriate immersion depth, install thermowell in an elbow on the axis of the pipe.
    - c. As identified on instrument data sheet.
- B. Provide sunshades for outdoor installations.

## **2.04 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
  - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.



## **ART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
  - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

### **3.02 PREPARATION (NOT USED)**

### **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Apply thermally conductive silicone grease to the sensor tip before insertion in thermowell.

### **3.04 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.05 ADJUSTING**

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

### **3.06 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.07 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.08 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.





### 3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.
  2. Contractor shall coordinate the selection of the material, ranges, span, and accessories and options with the process being measured to ensure a complete and operating system

END OF SECTION





## SECTION 17710

### CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
    - a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
    - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
    - c. Control components.
    - d. Control panel installation.
- B. Provide all control panels identified in Contract Documents.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
  - 2. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
  - 3. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
- C. International Electrotechnical Commission (IEC):
  - 1. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
  - 2. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
- D. Underwriters Laboratories Inc. (UL):
  - 1. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.



2. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
3. 508 - Standard for Industrial Control Equipment.
4. 508A - Standard for Industrial Control Panel.
5. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
6. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
7. 1283 - Standard for Electromagnetic Interference Filters.
8. 1449 - Standard for Surge Protective Devices.

### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  1. The term "panel" in this Section is interchangeable with the term "enclosure."

### 1.04 SUBMITTALS

- A. Provide submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
  1. Product data:
    - a. Enclosure construction details and NEMA type.
    - b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
  2. Shop drawings:
    - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
      - 1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
    - b. Complete nameplate engraving schedule.
    - c. Structural details of fabricated panels.
  3. Calculations:
    - a. Provide installation details based on calculated shear and tension forces:
      - 1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
    - b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
      - 1) Weight including panel internal components.
      - 2) Seismic forces and overturning moments.
      - 3) Shear and tension forces in connections.
    - c. Cooling calculations, including but not limited to:
      - 1) Highest expected ambient temperature for the enclosure's location.
      - 2) Internal heat load.
      - 3) Exposure to direct sunlight.
      - 4) Dimensions of the enclosure in inches.



- 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:

1. Seismic panel construction:
  - a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612 - Seismic Design Criteria:
    - 1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
  - b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612 - Seismic Design Criteria. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

## 1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
  1. Provide all components and equipment with UL 508 listing.
  2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
  3. Provide fuses for all equipment that is not UL or UR listed.
  4. Install all intrinsically safe circuits and equipment in accordance with UL698A.

## 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

## 1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

## 1.08 SEQUENCING (NOT USED)

## 1.09 SCHEDULING (NOT USED)



## **WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **1.11 SYSTEM START-UP (NOT USED)**

### **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

### **1.13 COMMISSIONING (NOT USED)**

### **1.14 MAINTENANCE (NOT USED)**

## **PART 2 PRODUCTS**

### **2.01 MANUFACTURERS**

- A. As listed below in the individual component paragraphs.
- B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

### **2.02 SYSTEM DESCRIPTION**

- A. Panel dimensions:
  - 1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
    - a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
    - b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
    - c. Maximum panel depth: 30 inches, unless otherwise indicated.
- B. Structural design:
  - 1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

### **2.03 EXISTING PRODUCTS (NOT USED)**

### **2.04 MATERIALS**

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
  - 1. Enclosures shall have the following properties:
    - a. NEMA Type 1: Steel.
    - b. NEMA Type 4: Steel with gasketed door, raintight.



- c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
- d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
- e. NEMA Type 12: Steel with gasketed door, dusttight.
- f. NEMA Type 7: Cast aluminum.

B. Bolting material:

- 1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
- 2. Carriage bolts for attaching end plates.
- 3. All other bolted joints shall have S.A.E. standard lock washers.

## 2.05 MANUFACTURED UNITS

A. Panels/enclosures:

- 1. Manufacturers: One of the following or equal:
  - a. Rittal.
  - b. nVent/Hoffman.
  - c. Saginaw Control & Engineering.
- 2. Panel assembly:
  - a. General guidelines for panel fabrication include:
    - 1) Continuous welds ground smooth.
    - 2) Exposed surfaces free of burrs and sharp edges.
    - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
  - b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
- c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.



- e. Door construction:
  - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
  - 2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
  - 3) Heavy-gauge stainless steel hinges.
  - 4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
  - 5) Gasket installed to seal against roll lip on the enclosure opening.
- f. Latches:
  - 1) For panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
    - a) Provide padlock for each enclosure with padlock provisions.
  - 2) Include an oiltight key-locking, 3-point latching mechanism on each door:
    - a) Provide 2 keys per panel.
    - b) All locks keyed alike.
  - 3) For large NEMA Type 4 and NEMA Type 4X cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
- g. Panel cut-outs:
  - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
  - 2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
  - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
    - a) Large panel cutouts; for example, openings for local operator interfaces.
    - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
- 3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
  - a. Minimum 14-gauge, Type 304 stainless steel.
  - b. Captive stainless steel cover screws threaded into sealed wells.
  - c. Inside finish: White polyester powder coating.
  - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
- 4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
  - a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
  - b. Door hardware: 316 Stainless steel.
  - c. Provide factory installed rain canopy and sun shield for all enclosures with operator interface panels.
  - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.





- B. Arrangement of components:
1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
  2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
  3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
  4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
- C. Overcurrent protection:
1. Main overcurrent device:
    - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
      - 1) Door-mounted disconnect handles are not acceptable.
      - 2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
      - 3) Provide means to defeat the interlock.
      - 4) Lockable in the off position.
    - b. Control panels supplied with 120 VAC:
      - 1) Provide an internal breaker with the line side terminals covered by a barrier.
      - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
  2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
  3. Selection and ratings of protective devices:
    - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
    - b. Voltage rating: Not less than the voltage of the application.
    - c. Select current rating and trip characteristics to be suitable for:
      - 1) Maximum normal operating current.
      - 2) Inrush characteristics.
      - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
    - d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
      - 1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
      - 2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
      - 3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.



4. Provide a separate protective device for each powered electrical device:
  - a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
  - b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
    - 1) Size external fuse to open before any I/O-card-mounted fuses.
  - c. Individual discrete inputs shall use a 1/2-ampere fuse.
    - 1) Control loops shall use a 5-ampere fuse.
  - d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for 4-to- 20 milliamperes signals:
  - a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
    - 1) Label shall not cover or interfere with equipment manufacturer's instructions.
  - b. An individual 1/2-ampere fuse for each 4-to-20 milliamperes analog loop powered from the control panel.
  - c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
  - d. Manufacturers: One of the following or equal:
    - 1) Ferraz Shawmut.
    - 2) Littelfuse.
    - 3) Bussmann.
6. Fuse holders:
  - a. Modular type:
    - 1) DIN rail mounting on 35-millimeter rail.
    - 2) Touch-safe design: All connection terminals to be protected against accidental touch.
    - 3) Incorporates blown-fuse indicator.
    - 4) Plug-in style fuse terminals and fuse plugs are not acceptable.
  - b. Provide nameplate identifying each fuse:
    - 1) As specified in Section 16075 - Identification for Electrical Systems.
  - c. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, UT4-HESI Series.
    - 2) Allen-Bradley, 1492-FB Series B.
7. Control circuit breakers:
  - a. DIN rail mounting on 35-millimeter rail.
  - b. Manual OPEN-CLOSE toggle switch.
  - c. Rated for 250 VAC.
  - d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
  - e. Current ratings: As required for the application.
  - f. Provide nameplate identifying each circuit breaker:
    - 1) As specified in Section 16075 - Identification for Electrical Systems.
  - g. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, TMC Series.
    - 2) ABB.
    - 3) Allen-Bradley.
    - 4) Square D.
8. Electronic circuit protectors:
  - a. Used where a NEC Class 2 power circuit is required to protect devices with NEC Class 2 power supplies.



- b. DIN rail mounting on 35-millimeter rail.
- c. Rated for 24 VDC.
- d. 4 channels to feed 4 independent power feeds to separate devices.
- e. Output current ratings: As required for the application.
- f. LED input status indication.
- g. LED failure status of each channel indication.
- h. Fail contacts.
- i. Provide nameplate identifying each circuit electronic circuit protector module:
  - 1) As specified in Section 16075 - Identification for Electrical Systems.
- j. Manufacturers: One of the following or equal:
  - 1) Rockwell Automation 1692-TD014.
  - 2) Puls PISA11 series.

D. Conductors and cables:

- 1. Power and control wiring:
  - a. Materials: Stranded, soft annealed copper.
  - b. Insulation: 600 volts type MTW.
  - c. Minimum sizes:
    - 1) Primary power distribution: 12 AWG.
    - 2) Secondary power distribution: 14 AWG.
    - 3) Control: 16 AWG.
  - d. Color:
    - 1) AC power (line and load): Black.
    - 2) AC power (neutral): White.
    - 3) AC control: Red.
    - 4) AC control: Orange for foreign voltages.
    - 5) DC power and control (ungrounded): Blue.
    - 6) DC power and control (grounded): White with Blue stripe.
    - 7) Ground: Green.
- 2. Signal cables:
  - a. Materials: Stranded, soft annealed copper.
  - b. Insulation: 600 volts, PVC outer jacket.
  - c. Minimum size: 18 AWG paired triad.
  - d. Overall aluminum shield (tape).
  - e. Copper drain wire.
  - f. Color:
    - 1) 2-Conductor:
      - a) Positive (+): Black.
      - b) Negative (-): White and red.
    - 2) 3-Conductor:
      - a) Positive (+): Black.
      - b) Negative (-): Red.
      - c) Signal: White.
  - g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:

- 1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
- 2. Readily identified without twisting the conductor.



F. General wiring requirements:

1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
5. Provide power surge protection for all control panels.
6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
7. Provide non-metallic ducts for routing and organization of conductors and cables:
  - a. Provide wiring separation plan.
  - b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
  - c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
    - 1) 120 VAC: Grey colored ducts.
    - 2) 24 VDC: White colored ducts.
8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
  - a. Screw-on cable tie mounts.
  - b. Hammer-on cable-tie mounting clips.
  - c. Fingers of the nonmetallic duct.
9. Wire ties:
  - a. No wire ties inside wire duct.
  - b. Use Panduit Cable tie installation tool, with tension control/cutoff.
  - c. Verify cut ends are cut flush filed smooth after installed.
10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
  - a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
14. The control panel shall be the source of power for all 120-VAC devices interconnected with the control panel including, but not limited to:
  - a. Solenoid valves.
  - b. Instruments both mounted in the control panel and remotely connected to the control panel.

- G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams Indicated on the Drawings or as specified.



## 2.06 EQUIPMENT (NOT USED)

## 2.07 COMPONENTS

### A. Thermal management:

1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
2. Air conditioner:
  - a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interfaces, panel instruments, programmable logic controllers, or remote I/O.
  - b. Provide filters on intake and exhaust openings.
  - c. Increase panel sizes as needed to accommodate cooling units.
  - d. Enclosure rating: NEMA Type 4X.
  - e. Closed-loop design.
  - f. Power supply: 120 VAC.
  - g. Manufacturers: The following or equal:
    - 1) Kooltronic, GuardianX DP Series.
    - 2) ICEcube, Blade series or IECEx/ATEX for Zone 1 & 2.
3. Heating:
  - a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
    - 1) The panel is not supplied with 120 VAC power.
    - 2) There are no electronics or moisture-sensitive devices in the enclosure.
    - 3) The panel is smaller than 38 inches high.
4. Heat exchanger:
  - a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
  - b. Filterless design to facilitate easy cleaning of the core.
  - c. Mounting: As indicated on the Drawings.
  - d. Manufacturers: The following or equal:
    - 1) Noren, CC Series.
    - 2) ICEcube, Blade series.
5. Enclosure temperature switch:
  - a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
  - b. Sensor and electronic enclosure.
  - c. Accuracy: Within 2 degrees Fahrenheit.
  - d. Single contact:
    - 1) Manufacturers: One of the following or equal:
      - a) nVent/Hoffman ATEMNC.
      - b) Pfannenberger FLZ.
  - e. Dual contact:
    - 1) Manufacturers: The following or equal:
      - a) nVent/Hoffman ADLTEMP.



6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
  - a. Provide as indicated on the Drawings or as specified.
7. Fan ventilation:
  - a. Provide nVent/Hoffman fan speed control:
    - 1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
    - 2) Provide finger-guard kit.
    - 3) Filter kit with 2 spare filters for each intake fan.
    - 4) Provide bezel and gasket kit.
    - 5) Provide fan shroud.
    - 6) Automatically adjust fan speed depending on remote temperature sensor input.
    - 7) 120 VAC, 60 hertz.
    - 8) NEMA Type 5-15R cord connections.
- B. Pilot devices:
  1. General:
    - a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
    - b. Size:
      - 1) 30.5 millimeters.
    - c. Heavy duty.
    - d. Pushbuttons:
      - 1) Contacts rated:
        - a) NEMA Type A600.
      - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
    - e. Selector switches:
      - 1) Contacts rated:
        - a) NEMA Type A600.
        - b) Knob type.
      - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
      - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
    - f. Pilot lights:
      - 1) Type:
        - a) LED for interior installations.
      - 2) Push to test.
      - 3) Lamp color:
        - a) On/Running/Start: Red.
        - b) Off/Stop: Green.
        - c) Power: White.
        - d) Alarm: Amber.
        - e) Status or normal condition: White.
        - f) Opened: Red.
        - g) Closed: Green.
        - h) Failure: Red.
  2. Indoor and outdoor areas:
    - a. NEMA Type 4/13.
    - b. Manufacturers: One of the following or equal:



- 1) Allen-Bradley, Type 800T.
    - 2) Schneider Electric, Class 9001, Type K.
    - 3) General Electric, Type CR104P.
    - 4) IDEC, TWTD Series.
  3. Corrosive areas:
    - a. NEMA Type 4X.
    - b. Corrosion resistant.
    - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
    - d. Manufacturers: One of the following or equal:
      - 1) Cutler Hammer, Type E34.
      - 2) Schneider Electric, Class 9001, Type SK.
      - 3) Allen-Bradley Type 800H.
      - 4) IDEC, TWTD Series.
  4. Hazardous (Classified) Areas/Class I Division 2:
    - a. NEMA Type 4X.
    - b. Corrosion resistant.
    - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
      - 1) All contacts contained within a hermetically sealed chamber:
        - a) Pushbuttons.
        - b) Selector switches.
        - c) Push-to-test contacts on pilot lights.
      - 2) UL listed and labeled for Class I Division 2 areas.
    - d. Manufacturers: One of the following or equal:
      - 1) Cutler Hammer, Type E34.
      - 2) Allen-Bradley, Type 800H.
  5. Hazardous (Classified) Areas/Class I Division 1:
    - a. Corrosion resistant.
    - b. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
      - 1) All contacts contained within a hermetically sealed chamber:
        - a) Pushbuttons.
        - b) Selector switches.
        - c) Push-to-test contacts on pilot lights.
      - 2) UL listed and labeled for Class I Division 1 areas.
    - c. Manufacturers: One of the following or equal:
      - 1) Cutler Hammer, Type E34.
      - 2) Allen-Bradley, Type 800H.
- C. Signal isolators and converters:
  1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    - a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
    - b. Adjustable span and zero.
    - c. Accuracy: Within 1.0 percent of span.
    - d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
  2. Manufacturers: One of the following or equal:
    - a. Phoenix Contact, Mini Analog Pro.
    - b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
    - c. Action Instruments, Q500 Series or Ultra SlimPakII.





- d. AGM Electronics, Model TA-4000.
- e. Moore Industries, MIT 4-Channel.

D. Relays:

- 1. General:
  - a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
  - b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
  - c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
- 2. General purpose:
  - a. Magnetic control relays.
  - b. NEMA ratings:
    - 1) 300 volts.
    - 2) 10 Amps thermal continuous test current.
    - 3) 60 Amps make.
    - 4) 6 Amps break.
  - c. Plug-in type.
  - d. LED indication for energization status.
  - e. Coil voltages: As required for the application.
  - f. Minimum poles: DPDT.
  - g. Touch-safe design: All connection terminals to be protected against accidental touch.
  - h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
  - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
  - j. Relays with screw-type socket terminals.
  - k. Provide additional (slave/interposing) relays when the following occurs:
    - 1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
    - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
  - l. DIN rail mounting on 35-millimeter rail.
  - m. Ice-cube-type relays with retainer clips to secure relay in socket.
  - n. Integrated label holder for device labeling.
  - o. Manufacturers: One of the following or equal:
    - 1) Potter and Brumfield: Type KRP or KUP.
    - 2) IDEC: R\* Series (\* = H, J, R, S, U).
    - 3) Allen-Bradley: Type 700 HC.
    - 4) Square D: Type K.
- 3. Terminal block relays:
  - a. Magnetic control relays.
  - b. For use as an interposing relay for PLC based discrete I/O signals.
  - c. NEMA ratings:
    - 1) 250 volts.
    - 2) 6 Amps continuous.
    - 3) 1,500 volt-amperes make.
  - d. Plug-in type.
  - e. LED indication for energization status.
  - f. Coil voltages: As required for the application.
  - g. Minimum poles: SPDT.





- h. Touch-safe design: All connection terminals to be protected against accidental touch.
- i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
- j. Relays with screw-type socket terminals.
- k. DIN rail mounting on 35-millimeter rail.
- l. Integrated label holder for device labeling.
- m. Manufacturer: One of the following or equal:
  - 1) Phoenix Contact PLC Series.
  - 2) Eaton XR TBR Series.
  - 3) IDEC RV8H Series.
  - 4) Allen-Bradley Type 700 HL TBR Series.
- 4. Latching:
  - a. Magnetic-latching control relays.
  - b. NEMA ratings:
    - 1) 300 volts.
    - 2) 5 Amps continuous.
    - 3) 360 volt-amperes make.
    - 4) 320 volt-amperes break.
  - c. Plug-in type.
  - d. DIN rail mounting on 35-millimeter rail.
  - e. Coil voltage: As required for the application.
  - f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
  - g. Touch-safe design: All connection terminals to be protected against accidental touch.
  - h. Clear cover for visual inspection.
  - i. Provide retainer clip to secure relay in socket.
  - j. Manufacturers: One of the following or equal:
    - 1) Square D, 8501, Type K.
    - 2) IDEC, RR2KP Series.

E. Terminal blocks:

- 1. DIN rail mounting on 35-millimeter rail.
- 2. Rated for 15 amperes at 600 volts.
- 3. Screw terminal type.
- 4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
- 5. Finger-safe protection for all terminals for conductors.
- 6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
- 7. Terminals: Plainly identified to correspond with markings on the diagrams:
  - a. Permanent machine-printed terminal identification.
- 8. Disconnect-type field signal conductor terminals with socket/screw for testing.
- 9. Identify terminals suitable for use with more than 1 conductor.
- 10. Position:
  - a. So that the internal and external wiring does not cross.
  - b. To provide unobstructed access to the terminals and their conductors.
- 11. Provide minimum 25-percent spare terminals.
- 12. Manufacturers: One of the following or equal:
  - a. Phoenix Contact, UT4 Series.
  - b. Allen-Bradley, 1492 Series.



- F. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
    - a. Mount to DIN rail via grounding foot with mounting screw.
    - b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
    - c. Not be used for grounding signal cable shields.
  2. Screw terminal type.
  3. DIN rail mounting on 35-millimeter rail.
  4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
  5. Finger-safe protection for all terminals for conductors.
  6. Terminals: Plainly identified to correspond with markings on the diagrams:
    - a. Permanent machine-printed terminal identification.
  7. Manufacturers: One of the following or equal:
    - a. Phoenix Contact, USKLG Series.
    - b. Allen-Bradley, 1492-JG Series.
- G. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
  2. Type:
    - a. Wide slot.
    - b. Narrow slot.
    - c. Round hole.
  3. Manufacturers: The following or equal:
    - a. Panduit.
    - b. Phoenix Contact.
    - c. Thomas & Betts.
    - d. Iboco.
- H. DIN rail:
1. Perforated steel.
  2. 35 mm width.
  3. 15 mm deep.
  4. Provide 2-inch offset using one of the following:
    - a. Offset brackets.
    - b. Preformed standoff DIN Rail Channel.
- I. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
    - a. Provide SPD for panel 120 VAC power entrances:
      - 1) Non-faulting and non-interrupting design.
      - 2) Provide line to neutral and neutral to ground surge protection.
    - b. Provide surge protection at secondary of main circuit breaker:
      - 1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
      - 2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
    - c. DIN rail mounting.
    - d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:



- 1) Gastight connections.
    - 2) Visual status indication of MOV status on the input and output circuits.
    - 3) Dry contact rated for remote status indication.
  - e. Approvals:
    - 1) Tested in accordance with IEC 61643-11.
    - 2) Tested in accordance with UL 1283.
    - 3) Tested in accordance with UL 1449.
    - 4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20  $\mu$ s waveform in accordance with IEEE C62.41.1 Category C Area.
  - f. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, Type SFP Filter.
    - 2) ASCO, Model 277.
2. 24 VDC control panel power SPD:
  - a. Provide SPD for 24VDC power circuits.
  - b. Provide surge protection at DC power supply output.
  - c. DIN rail mounting.
  - d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
    - 1) Optical status indicator.
    - 2) Dry contact rated for remote status indication.
  - e. Approvals:
    - 1) Tested in accordance with IEC 61643-11.
  - f. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, Plugtrab PLT-SEC-T3-24-FM-UT.
3. Panel mounted control, signal, and data line SPD:
  - a. General:
    - 1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
    - 2) Approvals:
      - a) Tested in accordance with IEC 61643-21.
      - b) Tested in accordance with UL 497B.
    - 3) SPD shall consists of 2 parts:
      - a) Base module:
        - (1) DIN rail mounting.
        - (a) Grounded to DIN rail via mounting rail foot.
      - b) Plug protection module:
        - (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
    - 4) Provide indirect shield ground style SPD unless otherwise noted.
    - 5) Provide ability to locally identify and indicate SPD health.
    - 6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
    - 7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
    - 8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.
  - b. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, Plugtrab PT-IQ Series.
    - 2) Dehn, Blitzductor XTU Series.
4. Copper Ethernet SPD:



- a. Protects network equipment from lightning or other surge events.
  - b. Suitable for Gigabit networks.
  - c. Compatible with shielded Cat 6 cabling with shielded RJ-45 ports.
  - d. Compliant with PoE standards IEEE 802.3af and 802.3at.
  - e. Nominal discharge surge current: 10 kA.
  - f. Approvals:
    - 1) Tested in accordance with IEC 61643-21.
    - 2) Tested in accordance with UL 497B.
  - g. Manufacturers: One of the following or equal:
    - 1) Phoenix Contact, DT-LAN-CAT6+.
    - 2) Weidmuller, VDATA CAT6.
    - 3) Eaton/MTL, ZoneBarrier.
5. Field device mounted SPD:
- a. Conduit entry mounting.
    - 1) Provide parallel or through wiring configurations as required by the application.
      - a) Use parallel wiring configuration if there is an available cable gland at the device.
      - b) Use through wiring configuration if there is no available cable gland at the device.
    - 2) Provide Screw connections compatible with field device.
  - b. NEMA 4X 316 stainless steel material housing.
  - c. Approvals:
    - 1) Tested in accordance with IEC 61643-21.
  - d. 4-wire field device:
    - 1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
      - a) Maximum continuous voltage:
        - (1) DC:
          - (a) Signal: 32 VDC.
          - (b) Power supply: 255 VDC.
        - (2) AC:
          - (a) Signal: 22.6 VAC.
          - (b) Power supply: 255 VAC.
      - 2) Manufacturers: The following, engineer knows of no equal:
        - a) Endress+Hauser, HAW569-CB2C.
    - e. 2-wire or 3-wire field device:
      - 1) Module shall provide protection for the signal cable, communication bus or data line.
      - 2) Manufacturers: One of the following or equal:
        - a) Endress+Hauser, HAW569 Series.
        - b) Phoenix Contact, Surgetrab S-PT Series.
        - c) Eaton/MTL, TP Series.

J. Power supplies:

    - 1. Design power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
    - 2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
    - 3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.



4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
  - a. Provide automatic switchover upon module failure.
  - b. Alarm contacts monitored by the PLC.
5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
6. Sized to provide 40-percent excess rated capacity.
7. UL 508C listed to allow full-rated output without de-rating.
8. Provide fuse or short-circuit protection.
9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
12. Touch-safe design: All connection terminals to be protected against accidental touch.
13. DIN rail mounting on 35-millimeter rail:
  - a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
15. Manufacturers: One of the following or equal:
  - a. Fully redundant:
    - 1) Phoenix Contact, Quint Power Supply with SFB technology.
      - a) Phoenix Contact, Quint.
    - 2) IDEC, PS5R Series:
    - 3) Sola.
    - 4) PULS.
  - b. Redundancy module:
    - 1) Phoenix contact, o-ring redundancy module.

## 2.08 ACCESSORIES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.
- D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- E. Provide nameplate to each panel as indicated on the Drawings:



1. Provide as specified in Section 16075 - Identification for Electrical Systems on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
  - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
  - b. Supply voltage, phase, frequency, and full-load current.
  - c. Power source or circuit ID.
  - d. Short-circuit current rating of the panel based on one of the following:
    - 1) Short-circuit current rating of a listed and labeled assembly.
    - 2) Short-circuit current rating established utilizing an approved method.
- F. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. The window shall meet the following requirements:
  1. Safety plate glass.
  2. Secured by rubber locking seal.
  3. Allow full viewing of devices issuing visual process data or diagnostics.
- G. Lighting:
  1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    - a. Covered or guarded.
    - b. Provide On-Off door-activated switches where indicated on the Drawings.
    - c. 120-volt, single-phase, 15-amp style plug.
    - d. Provide 4,000 K, 900 Lumens - LED fixture.
      - 1) Provide additional fixtures for every 36 inches of width.
- H. Receptacles:
  1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
  2. GFCI, 120-volt, single-phase, 15-amp style plug.
  3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.
- I. Grounding:
  1. Provide the following:
    - a. Grounding strap between enclosure doors and the enclosure.
    - b. Equipment grounding conductor terminals.
    - c. Provide equipment grounding busbar with lugs for connection of all equipment grounding wires.
    - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
  2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND," the letter "G," or the color green.
  3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
  4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
  5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
  6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.



7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Unless otherwise noted, connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.

J. Provide sunshades and insulation for all outdoor installations.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**

## **2.11 FINISHES**

### **A. Finishes:**

1. Metallic (non-stainless):
  - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
  - b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
  - c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
  - d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
  - a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

### **B. Colors:**

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

## **2.12 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

### **3.02 PREPARATION (NOT USED)**





3.03

## INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
- B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.
- D. Provide concrete housekeeping pads for freestanding enclosures.
  - 1. Refer to the structural typical details.
- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
  - 1. Undercoat floor-mounted panels.
- F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.
- G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.
- H. Protect all wiring from sharp edges and corners.
- I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the Loop Drawings prepared by the Contractor.
- J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.
- K. Side panels:
  - 1. Side panels shall be kept free off all control equipment and devices. Any deviation must be sent to the engineer in writing asking for a deviation.

### 3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

### 3.05 REPAIRS/RESTORATION (NOT USED)

### 3.06 RE-INSTALLATION (NOT USED)

### 3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### 3.08 ADJUSTING (NOT USED)





### **3.09 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.10 DEMONSTRATION AND TRAINING (NOT USED)**

### **3.11 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 17720

### CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Programmable logic controller (PLC) based control systems hardware.
  - 2. Development software to be used with the specified PLC hardware.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE).

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. CPU: Central processing unit.
  - 2. I/O: Input/Output.
- C. Specific definitions:
  - 1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
  - 2. Application software: The software that is programmed specifically for the Project.

##### 1.04 SYSTEM DESCRIPTION

- A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
  - 1. CPU:
    - a. Processor type.
    - b. Processor speed.
    - c. Memory.
    - d. Internal processor battery backup time.



2. I/O modules:
  - a. Type.
  - b. Standard wiring diagram.
- C. Calculations:
  1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
  2. Submit calculations to verify that spare I/O requirements of this Section are met.
  3. Submit calculations to verify that PLC power supply requirements of this Section are met.
- D. Product data:
  1. Programming languages.
  2. Operating system requirements.
- E. Control logic:
  1. Fully annotated copy of programmed PLC logic.
  2. Cross-referenced index of all PLC registers or points.
- F. Provide application software for the specific Project process requirements.
  1. Fully annotated copy of programmed PLC logic in its native format.
  2. Cross-referenced index of all PLC registers or points.

#### **1.06 QUALITY ASSURANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.
- C. Additional requirements:
  1. Provide PLC system components by a single manufacturer:
    - a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
  2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
  3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.08 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



## **1.09 SEQUENCING (NOT USED)**

## **1.10 SCHEDULING (NOT USED)**

## **1.11 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## **1.12 SYSTEM START-UP (NOT USED)**

## **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

## **1.14 COMMISSIONING (NOT USED)**

## **1.15 MAINTENANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. In addition to the spare parts requirements specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems
  - 1. CPU: 1 spare for each type of CPU in the system.
  - 2. I/O cards: 3 spares for each type of I/O card in the system.
  - 3. Power supplies: 2 spares for every power supply in the system.
  - 4. Network/communications cards: 1 spare for every network or communications card in the system.
  - 5. Remote adaptor: 1 spare for every remote adaptor in the system.
  - 6. Chassis: 1 spare for each chassis size in the system.
  - 7. Communication cable: 1 spare for each type of cable used in the system.
- C. Installed spare requirements:
  - 1. I/O points:
    - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
    - b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
  - 2. PLC backplane capacity:
    - a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
  - 3. PLC memory:
    - a. Provide 50-percent spare program volatile memory.

# **PART 2 PRODUCTS**

## **2.01 MANUFACTURERS**

- A. One of the following or equal:
  - 1. Rockwell Automation:
    - a. CompactLogix.
  - 2. Modicon:
    - a. M580.



- b. Momentum.
    - c. M340.
  - 3. General Electric:
    - a. RX3i.
    - b. VersaMax.
    - c. VersaMax Micro.
- B. The PLC programming software system shall be manufactured by PLC hardware manufacturer:
  - 1. Rockwell Software:
    - a. RSLogix 5000.
    - b. Studio 5000.
  - 2. Modicon:
    - a. Unity Pro.
  - 3. General Electric, Proficy Machine Edition with Logic Developer - PLC.

## **2.02 EXISTING PRODUCTS (NOT USED)**

## **2.03 MATERIALS (NOT USED)**

## **2.04 MANUFACTURED UNITS**

- A. Programmable logic controller:
  - 1. Construction:
    - a. Furnish plug-in modular system.
    - b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
      - 1) Temperature: 0 to 60 degrees Celsius.
      - 2) RFI: 80 to 1,000 MHz.
      - 3) Vibration: 10 to 500 hertz.
      - 4) Humidity: 0 to 95 percent.
    - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
    - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
      - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
  - 2. CPU:
    - a. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
    - b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
    - c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.



3. Memory:
  - a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
  - b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
    - 1) Reserve capacity:
      - a) Totally free from any system use.
    - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
4. Programming:
  - a. Provide a system where processors are programmed by:
    - 1) Portable laptop computer both locally and via the PLC control network.
5. PLC power supply:
  - a. Input: 120 VAC.
  - b. Mounted in the PLC housing or as indicated on the Drawings.
  - c. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
6. PLC input/output, I/O modules:
  - a. General:
    - 1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
    - 2) Provide I/O modules that:
      - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
      - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
      - c) Accept dual-ended inputs.
    - 3) The use of common grounds between I/O points is not acceptable.
    - 4) Provide modules that are removable without having to disconnect wiring terminals:
      - a) Utilize a swing-arm or plug-in wiring connector.
    - 5) Provide at each PLC the I/O modules for the following:
      - a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
      - b) Installed spare capacity in accordance with the requirements of this Section.
      - c) Wire all spares provided to the field terminal strip.
    - 6) Condition, filter, and check input signals for instrument limit conditions.
    - 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
    - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
    - 9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.



- 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
- b. Discrete input modules:
  - 1) Defined as contact closure inputs from devices external to the input module.
  - 2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
  - 3) Individually isolated inputs.
  - 4) With LEDs to indicate status of each discrete input.
- 1) Input voltage: 120VAC.
- 2) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
  - a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.
- c. Discrete output modules:
  - 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
    - a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
  - 2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
  - 3) LEDs to indicate status of each output point.
  - 4) Output voltage: 120VAC.
  - 5) Individually isolated outputs.
- d. Analog input modules:
  - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
  - 2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
  - 3) The analog-to-digital conversion updated with each scan of the processor.
  - 4) Individually isolated each input.
  - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
- e. Analog output modules:
  - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
  - 2) Individual isolated output points each rated for loads of up to 1,000 ohms.
- f. Specialty I/O modules:
  - 1) Resistance temperature detector (RTD) input module:
    - a) Channels per module: 4 minimum.
    - b) RTD types accepted:
      - (1) 100-ohm platinum.





- (2) 200-ohm platinum.
        - (3) 500-ohm platinum.
        - (4) 1,000-ohm platinum.
        - (5) 100-ohm nickel.
        - (6) 200-ohm nickel.
        - (7) 500-ohm nickel.
        - (8) 10-ohm copper.
      - c) Provide input module that accepts 2-, 3-, or 4-wire RTD.
    - g. Network communications modules:
      - 1) General:
        - a) Install communications modules in the PLC backplane.
      - 2) Ethernet:
        - a) Ports: 1RJ-45.
        - b) Communication rate: 100 Mbit/s.
      - 3) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
  7. PLC backplane housing:
    - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
    - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
    - c. Provide a blank slot filler module for each spare slot.
- B. PLC programming software:
1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
    - a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
    - b. Monitor devices at each drop on the PLC data network for proper communications.
    - c. Provide the ability to program all PLCs on the PLC data network from the Engineer's console.
  2. PLC programming laptop/desktop operating system:
    - a. Microsoft Windows 10.
  3. The PLC programming software shall be suitable for the PLCs specified above.
  4. PLC programming software for all programming, monitoring, searching, and editing:
    - a. Usable both on-line, while connected to the PLC, and off-line.
    - b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
    - c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
    - d. Include a search capability to locate any address or element and its program location.
    - e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
  5. The PLC programming software shall support the following programming languages:
    - a. Ladder Diagram.



6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
  - a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
  - b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
  - c. Use a mnemonic associated with each contact, coil, etc. that describes its function.
  - d. Utilize the tag and loop identification as contained in the P&IDs:
    - 1) If additional internal coils, timers, etc. are used for a loop, they shall contain the loop number.
  - e. Provide a cross-reference report of program addresses.
7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
  - a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
    - 1) Respond to demands from a program request.
    - 2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
    - 3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
    - 4) Queuing of requests in order of priority if one or more requested resources are unavailable.
    - 5) Resolution of contending requests for the same resource in accordance with priority.
    - 6) Service requests for execution of one program by another.
    - 7) Transfer data between programs as requested.
    - 8) Management of all information transfers to and from peripheral devices.
    - 9) Control and recovery from all program fault conditions.
    - 10) Diagnose and report real-time hardware device errors.
8. Program execution:
  - a. Application software - program execution scheduled on a priority basis:
    - 1) A multilevel priority interrupt structure is required.
    - 2) Enter into a list of pending programs a program interrupted by a higher priority program:
      - a) Resume its execution once it becomes the currently highest priority program.
    - 3) Schedule periodic programs.
    - 4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
9. Start-up and restart:
  - a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
  - b. Initialization:
    - 1) Determination of system status before start-up of initializing operating system software and initializing application software.



- 2) Loading of all memory-resident software, initializing timers, counters and queues, and initialization of all dynamic database values.
10. Shutdown:
  - a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
  - b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
  - c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
  - d. Alarm PLC failure at the operator interface level.
11. Diagnostics:
  - a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
  - b. Use the manufacturer's standard diagnostic routines as much as possible.
  - c. Furnish diagnostic software and test programs for each significant component in the control system.
  - d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
12. Calendar/time program:
  - a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system-level and application software.
  - b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
  - c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
  - a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
  - b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
  - c. Algorithms must include alarm checks where appropriate.
  - d. Provide, as a minimum, the following types of algorithms:
    - 1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
    - 2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
    - 3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
    - 4) Lead, lag, dead time, and ratio compensators.
    - 5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
  - a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.



16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:
  - a. Analog input signal types:
    - 1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
  - b. Input accuracy:
    - 1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
    - 2) Data conversion errors must be less than 0.05-percent full-scale.
    - 3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
    - 4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
  - c. Blocking:
    - 1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
    - 2) For any input so blocked, the operator may manually enter a value to be used as the input value.
  - d. Filtering:
    - 1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
  - e. Linearizing:
    - 1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
  - f. Calculated values:
    - 1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
    - 2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
  - g. Scaling and zero suppression:
    - 1) Provide a conversion program to convert input values into engineering units in a floating-point format.
  - h. Alarms:
    - 1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
    - 2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
    - 3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
    - 4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.



- i. Averages:
  - 1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
  - 2) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
  - 3) Update hourly averages each minute or at the polling interval for the selected variable.
  - 4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
  - 5) Update monthly averages at least once each day and calculate using the results of the daily averages.
  - 6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
  - 7) The active database must include the present period average and previous period average for each variable and averaging period.
- j. Totals:
  - 1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
  - 2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
  - 3) Assign a separate factor for each totalizing interval.
  - 4) Variables for which totalization is inappropriate must have scaling factors of zero.
  - 5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
  - 6) The active database must include the present period total and previous period total for each variable and totalizing period.
- k. Engineering units:
  - 1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
  - 2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
  - 3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
  - 4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
  - 5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.
- l. Control modules:
  - 1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
  - 2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.



- 3) Provide control algorithms for manual control with output values adjustable by the operator.
  - m. Analog outputs:
    - 1) Analog outputs must be maintained as part of the database.
    - 2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.
  18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.
- C. General control functions:
1. Analog control functions:
    - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
    - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
    - c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
    - d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
  2. Discrete control functions:
    - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
  3. Software support:
    - a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
    - b. Call each function as required by the configured controls to perform the intended function.
  4. Control and status discrepancies:
    - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
      - 1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
    - b. Involuntary change in the device's status must also generate an alarm:
      - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
    - c. Each command, status, and alarm must cause the color of the symbol to change.
    - d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
      - 1) Delay periods for each final control element must be adjustable at the operator interface.
      - 2) List all time delays in the final documentation.





5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. Control configuration:

1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.
2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints, tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

**2.05 EQUIPMENT (NOT USED)**

**2.06 COMPONENTS (NOT USED)**

**2.07 ACCESSORIES (NOT USED)**

**2.08 MIXES (NOT USED)**

**2.09 FABRICATION (NOT USED)**

**2.10 FINISHES (NOT USED)**

**2.11 SOURCE QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

**PART 3 EXECUTION**

**3.01 EXAMINATION (NOT USED)**

**3.02 PREPARATION (NOT USED)**

**3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:



1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. General:
  1. The control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- F. Program the PLC logic using the following language(s):
  1. Ladder Diagram.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION**

- A. Provide a minimum of 4 CD/DVD copies of the following:
  1. Application software:
    - a. Finalized fully annotated copy of programmed PLC logic in its native format.
    - b. Cross-referenced index of all PLC registers or points.

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 FIELD QUALITY CONTROL**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.08 ADJUSTING (NOT USED)**

#### **3.09 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **3.10 DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.
- C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
  1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer's training course for the PLC hardware.





2. A representative of the ICSC may perform the PLC programming software training only if the representative has completed the manufacturer's training course for the PLC programming software.

### **3.11 PROTECTION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION





## SECTION 17733

### CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Materials and equipment used in process control and LAN networks including:
    - a. Network switches.
    - b. Media converters.
    - c. Routers.
    - d. Patch panels and other data network hardware.
    - e. Related accessories.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. 802.1X – Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
  - 2. 802.3 - Standard for Ethernet.
  - 3. 802.3ab - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T.
  - 4. 802.3u - Standards for Local and Metropolitan Area Networks: Supplement - Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BASE-T (Clauses 21-30).
  - 5. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
- C. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
  - 1. 568-C.3 - Optical Fiber Cabling Components Standard.
- D. Underwriters Laboratories, Inc. (UL).

##### 1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



04

## SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
  - 1. Include information on all network equipment.
  - 2. Manufacturer's operation and installation instructions.
- C. Shop drawings:
  - 1. Complete set of drawings including but not limited to:
    - a. System block diagram showing relationship and connections between devices provided under this Contract **and existing equipment**. Include manufacturer and model information, and address settings.
    - b. Network riser diagram.
    - c. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
    - d. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, and nameplates.
    - e. Electrical connection diagrams.
    - f. Complete grounding requirements.
  - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
    - a. Manufacturer's model number.
    - b. Project equipment tag.
  - 3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
    - a. Quantity.
    - b. Description.
    - c. Manufacturer.
    - d. Part numbers.
- D. Test reports:
  - 1. As specified in Sections:
    - a. 16125 - Fiber Optic Cable and Appurtenances.
    - b. 17950 - Commissioning for Instrumentation and Controls.
  - 2. Signed test results as described in this Section.
  - 3. Test results shall include:
    - a. Narrative describing the test procedures followed.
    - b. Block diagram of test set up.
    - c. Manufacturer's information on test equipment used.
    - d. Detailed test results.
    - e. A narrative summarizing the results of the testing and identifying any further action required.
- E. Operating manuals:
  - 1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



- F. Record drawings:
1. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
  2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

#### **1.05 QUALITY ASSURANCE**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.06 DELIVERY, STORAGE, AND HANDLING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.07 PROJECT OR SITE CONDITIONS**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.08 SEQUENCING (NOT USED)**

#### **1.09 SCHEDULING (NOT USED)**

#### **1.10 WARRANTY**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.11 SYSTEM START-UP (NOT USED)**

#### **1.12 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.13 COMMISSIONING (NOT USED)**

#### **1.14 MAINTENANCE (NOT USED)**

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS (NOT USED)**

#### **2.02 SYSTEM DESCRIPTION**

- A. Provide all network equipment identified in the Contract Documents.

#### **2.03 EXISTING PRODUCTS (NOT USED)**

#### **2.04 MATERIALS (NOT USED)**



05

## MANUFACTURED UNITS

### A. Unmanaged Ethernet switches:

1. Manufacturers: One of the following or equal:
  - a. Moxa, 308/305 Series.
  - b. N-Tron.
  - c. Hirschmann.
2. Properties:
  - a. Hardware:
    - 1) 10/100BASE-FX.
    - 2) 100BASE-FX.
    - 3) Power supply:
      - a) Provide redundant power supplies.
      - b) 24 VDC, 200 watts/per power supply.
      - c) Store and forward.
    - 4) No fans or moving parts.
  - b. Performance:
    - 1) Full/half-Duplex.
    - 2) MDI/MDI-X Auto-sensing.
  - c. Environment:
    - 1) Operating temperature range: 32 to 140 Degrees Fahrenheit.
    - 2) Humidity: 5 to 95 percent, non-condensing.
  - d. The Ethernet switch shall be capable of performing basic switching without special programming or configurations.
  - e. Ports:
    - 1) As required to provide the number of connections required plus 10 percent spare of each type used.
  - f. Connector type:
    - 1) Fiber: SC.
    - 2) Copper: RJ-45.
  - g. Mounting:
    - 1) Din Rail.

### B. Media converters:

1. Copper to fiber transceiver:
  - a. Manufacturers: One of the following or equal:
    - 1) N-Tron.
    - 2) Transition Networks.
    - 3) Phoenix Contact.
  - b. Transceiver shall be used to convert from Half/Full Duplex Ethernet to multimode fiber Ethernet 100BASE-FX:
    - 1) Meets requirements of IEEE 802.3 Ethernet standard.
    - 2) Supports Half/Full Duplex.
    - 3) Connector type:
      - a) Fiber: SC.
      - b) Copper: RJ-45.
    - 4) Power supply:
      - a) 110 VAC, 60 hertz.
      - b) 24 VDC, 6 watts.
    - 5) Mounting:
      - a) Provide mounting hardware.
      - b) DIN rail mounting, unless otherwise indicated on the Drawings.



- C. Patch panels:
1. General:
    - a. Fiber:
      - 1) All optical fibers shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via fiber optic patch cords.
      - 2) All fibers, active and dark, shall be terminated at the patch panels.
      - 3) Interconnect and patch panel housings shall provide space for excess fiber and provide strain relief for the fiber cable.
      - 4) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
    - b. Copper:
      - 1) Final connections between the patch panel and network equipment shall be by patch cords.
      - 2) All premises cables shall be terminated at the patch panels.
      - 3) Cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out conductors.
      - 4) Maintain twist of broken out conductors per EIA/TIA standards.
  2. Cabinet style fiber patch panels:
    - a. DIN rail mounted:
      - 1) Use for the termination of a single cable inside of cabinets, in small enclosures or as indicated on the plans.
      - 2) DIN rail mounted cable interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
      - 3) DIN rail mounted cable interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
      - 4) Capacity:
        - a) As shown on the plans, minimum 6 connections.
      - 5) Accessories:
        - a) Blanks for unused connector panels.
      - 6) Manufacturers: One of the following or equal:
        - a) Hirschmann, MIPP.
        - b) DINSpace, SNAP XL.

## **2.06 EQUIPMENT (NOT USED)**

## **2.07 COMPONENTS (NOT USED)**

## **2.08 ACCESSORIES**

- A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.
- B. Furnish accessories as specified in Section 17730 - Control Systems: PCS Computer Equipment.

## **2.09 MIXES (NOT USED)**

## **2.10 FABRICATION (NOT USED)**



## **2.11 FINISHES (NOT USED)**

## **2.12 SOURCE QUALITY CONTROL (NOT USED)**

# **PART 3 EXECUTION**

## **3.01 EXAMINATION (NOT USED)**

## **3.02 PREPARATION (NOT USED)**

## **3.03 INSTALLATION**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system as indicated on the Drawings and as specified in this Section:
  - 1. Refer to SCADA block diagrams for all new network connections.
  - 2. Provide configuration for all managed Ethernet switches and other components including but not limited to VLAN (virtual local area network), additional Plant PLC communication cards and separate managed Ethernet switches as required, such that there is isolation of the following networks:
    - a. Field and PLC I/O network: This includes the connections between the Plant PLC and:
      - 1) Plant PLC expansion racks.
      - 2) Plant PLC remote I/O (RIO) racks.
      - 3) Field Networks.
      - 4) HMI(s) part of a Plant PLC.
      - 5) Vendor furnished Ethernet network components.
    - b. Valve Actuator network: This includes the connections between the Plant PLC and the valve master stations.
    - c. Process Control network: This includes the connections between the Plant PLC and other Plant PLCs.
    - d. SCADA network: This includes the connections between the various SCADA equipment including but not limited to servers (existing), workstations and printers.
    - e. Security network: This includes any security hardware with Ethernet communication as provided by the security/telephone/internet sub-contractor.
  - 3. The process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
  - 4. The enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.
- C. All racks shall be level and plumb.
- D. Install Velcro wrap on all cable bundles within the network rack/enclosure.





- E. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
  - 1. Cables shall be installed avoiding sharp bends.
  - 2. Install cable using lubricant designed for cable pulling.
  - 3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
  - 4. Install LAN cables without splices.
  - 5. Installed bend radii shall not exceed 4 times the cable diameter.
  - 6. Terminated all pairs at the jack and the patch panel.
- F. Install cables a minimum of 40 inches away from electrical motors and transformers.
- G. Install cables a minimum of 12 inches away from fluorescent lighting.
- H. Individual pairs will be untwisted less than 1/2-inch at termination points.
- I. All cables and terminations shall be labeled with cable designations as specified in Section 16075 - Identification for Electrical Systems.
- J. Each data port shall be individually labeled with its patch panel/switch port ID:
  - 1. Labeling must be printed - no handwritten labels will be allowed.
- K. At the completion of the wiring installation, provide the following documentation:
  - 1. A plan-view of the premise(s) showing the jack numbering scheme.
  - 2. A printed certification report for the entire wiring installation showing compliance with all EIA/TIA specifications for data cable.
  - 3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
  - 4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.

#### **3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**

#### **3.05 REPAIR/RESTORATION (NOT USED)**

#### **3.06 RE-INSTALLATION (NOT USED)**

#### **3.07 FIELD QUALITY CONTROL (NOT USED)**

#### **3.08 ADJUSTING**

- A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

#### **3.09 CLEANING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.



3.10

## **DEMONSTRATION AND TRAINING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.
- C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

### **3.11 PROTECTION (NOT USED)**

### **3.12 SCHEDULES (NOT USED)**

END OF SECTION



## SECTION 17950

### COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

#### PART 1 GENERAL

##### 1.01 SUMMARY

- A. Section includes:
  - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

##### 1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Electronics Industries Alliance (EIA).
- C. Telecommunications Industry Association (TIA).

##### 1.03 DEFINITIONS

- A. As specified in Sections 01756 - Commissioning and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
  - 1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
  - 2. Loop Validation Tests - Signals are tested from the field device to the PLC.
  - 3. Platform Testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.
  - 4. PTO: Profibus Trade Organization.

##### 1.04 SYSTEM DESCRIPTION (NOT USED)

##### 1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures.
- B. General:
  - 1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Overall test plan:
  - 1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.



2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
  3. Describe the test phases as they apply specifically to this Project and each process system.
  4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
  5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
  6. Provide examples of proposed forms and checklists.
- D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
  2. Provide a statement of test objectives for each test.
  3. Prepare specific procedures for each process system.
  4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
  5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
  6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
  7. Provide the forms and checklists to be used.
- E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
    - a. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
    - b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
    - c. Sample test forms at the end of this Section show the minimum required content.
      - 1) The sample test forms have not been customized for this Project.
      - 2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.
- F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
    - a. Control system testing block diagram.
    - b. Estimated test duration.



- G. Details on the simulator construction, components, and operation. Testing binders:
1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
  2. Fill out in advance headings and all other information known before the test.
  3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
  4. Include or list reference material and provide separately at the time of the test.
  5. Record test results and verify that all test requirements and conditions have been met.
- H. Test reports:
1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
  2. Include all completed test binders, forms, and checklists.
  3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

#### **1.06 QUALITY ASSURANCE**

- A. Test personnel:
1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

#### **1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)**

#### **1.08 PROJECT OR SITE CONDITIONS (NOT USED)**

#### **1.09 SEQUENCING (NOT USED)**

#### **1.10 SCHEDULING**

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

#### **1.11 WARRANTY (NOT USED)**

#### **1.12 SYSTEM START-UP (NOT USED)**

#### **1.13 OWNER'S INSTRUCTIONS (NOT USED)**

#### **1.14 MAINTENANCE (NOT USED)**

### **PART 2 PRODUCTS (NOT USED)**

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION (NOT USED)**



## 3.02 PREPARATION (NOT USED)

### 3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Installation supervision:
  - 1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## 3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

## 3.05 REPAIR/RESTORATION (NOT USED)

### 3.06 COMMISSIONING

- A. Commissioning as specified in Section 01756 - Commissioning.
- B. Testing and training phase:
  - 1. Source testing:
    - a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
17100 - Control Strategies	Control Strategies	Witnessed
17101 - Specific Control Strategies	Specific Control Strategies	Witnessed
17710 - Control Systems - Panels, Enclosures, and Panel Components.	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
17950 – Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

- b. Prerequisite requirements:
  - 1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.
- c. Preliminary FAT (Pre-FAT):
  - 1) The purpose of the Pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality.
    - a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
    - b) Contractor shall fully test the HMI/SCADA system and fix all deficiencies found before the FAT.
  - 2) Conduct utilizing test procedures approved by Engineer



- 3) Owner shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
  - 4) Submit a letter, signed by the Contractor's project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT.
    - a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.
  - 5) Engineer approval of the pre-FAT submittal is required before proceeding to FAT.
- d. FAT hardware and communications testing:
- 1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
  - 2) The complete PCIS system including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
  - 3) Testing simulation:
    - a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
    - b) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system.
      - (1) The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
      - (2) The simulator may consist of a PLC, operating under a HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
      - (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
  - 4) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
  - 5) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
  - 6) Verify communications between the hardware and the programmer's software comply with specified requirements.
    - a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio based telemetry systems.
  - 7) Panel inspections:
    - a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings.



- (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
  - b) Inspection forms:
    - (1) Provide panel inspection forms as part of the FAT procedures submittal.
    - (2) A sample FAT control panel form has been provided at the end of this Section.
- 8) I/O test:
  - a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
  - b) Test methodology:
    - (1) Discrete inputs:
      - (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
    - (2) Discrete outputs:
      - (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
    - (3) Analog inputs:
      - (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
      - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
    - (4) Analog outputs:
      - (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
      - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
  - c) Test forms to include, but not be limited to the following data:
    - (1) PLC and panel number.
    - (2) I/O type.
    - (3) I/O tag name.
    - (4) Rack/slot/number of I/O point.
    - (5) Check-off for correct response for each I/O point.
    - (6) Comments field.
    - (7) Initials of individual performing test.
    - (8) Date test was performed.
    - (9) Witness signature lines.
- 9) System configuration test:
  - a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.





- b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
  - c) Demonstrate the proper operation of peripheral hardware.
  - d) Demonstrate general HMI/SCADA functions.
  - e) Demonstrate proper operation of log-on and other security access functions.
  - f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
  - g) Test automatic fail over of redundant equipment.
  - h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
  - i) Test forms:
    - (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
    - (2) List the specific tests and steps to be conducted.
    - (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
      - (a) Include signature and date lines.
- 10) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
- e. FAT Platform Testing - Control logic test:
- 1) Verify the PLC, HMI and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
  - 2) Testing requirements:
    - a) Demonstrate each function described in the Control Strategies.
    - b) Demonstrate in detail how each function operates under a variety of operating scenarios.
      - (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
    - c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description.
      - (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
      - (2) Loops with similar or identical logic must each be tested individually.
      - (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
    - d) Demonstrate the proper operation of all digital communication links and networks.
      - (1) Verify each digital communication I/O point.
    - e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.



- 3) Test forms:
    - a) Submit completed test forms for each loop including but not limited to the fully revised and approved control strategy.
    - b) Identify the cause and effect as each I/O point is toggled through the simulator.
      - (1) Identify and track proper and/or improper operation of the loop.
    - c) Note any deficiencies or operational changes on the forms for correction and documentation:
      - (1) Include signature and date lines.
  - 4) Engineer approval of the FAT submittal is required prior to shipment of system components.
2. Owner training:
    - a. Demonstration requirements are specified in this Section.

Table 1			
Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	8	10	1
Operator Training - Basic	24	10	2
Operator Training - Advanced	16	5	2
PLC Hardware	16	4	1
PLC Software	32	6	1
LOI Hardware and Software	16	5	1
Network Equipment	16	4	1
Follow-Up Training	8	5	5
Instrument Training	24	3	1
Analytical Instrument Training	8	3	3

3. Installation testing:
  - a. Calibration:
    - 1) Performed by Contractor and ICSC.
    - 2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
  - 3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
    - a) Calibration for discrete devices:
      - (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.



- b) Calibration for ultrasonic and radar level devices:
    - (1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units.
      - (a) Submit printout of the actual transmission and parameters.
    - (2) Adjust mounting, as required, to obtain accurate readings.
    - (3) Post mounting: Provide any additional calibration required by manufacturer.
  - c) Calibrating analog transmitters:
    - (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
    - (2) Test and verify that components and/or systems are within the specified limits of accuracy.
    - (3) Calibration points:
      - (a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
    - (4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
  - d) Analyzer calibration:
    - (1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
    - (2) Submit completed instrument calibration sheets for every field instrument and analyzer.
    - (3) Calibration tags:
      - (a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
      - (b) Sign the tag when calibration is complete.
  - e) Calibration for industrial networking test equipment:
  - f) Submit calibration documentation.
- b. Loop check:
- 1) Performed by the Contractor.
  - 2) Cabling installed, terminated, and labeled.
  - 3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
  - 4) Complete loop check form for each device.
  - 5) Submit loop check test results before proceeding to the next step.
- c. Loop validation tests:
- 1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
  - 2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
    - a) The PLC may or may not be connected to the network.
  - 3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.



- d. Complete End-to-End Testing (CEET):
- 1) Performed by Contractor, ICSC, manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed.
    - a) The participants need to be dedicated full-time to CEET.
    - b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
    - c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
  - 2) Prerequisites:
    - a) CEET cannot begin until the successful completion of the preceding tests:
      - (1) Calibration.
      - (2) Loop check.
      - (3) Loop validation tests.
      - (4) LAN cable post-testing.
      - (5) Industrial network testing.
  - 3) Testing description:
    - a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
    - b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
    - c) SCADA screens:
      - (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
      - (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
      - (3) Retest any loop following any necessary corrections.
  - 4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system.
    - a) Use actual process inputs wherever available.
    - b) Issue commands from the HMI/SCADA system and verify proper responses of field devices.
      - (1) Test SCADA system inputs from field device to SCADA system operator workstations.
        - a) Track responses through trend charts in the HMI/SCADA system.
      - (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.



- 2) Discrete device testing:
  - a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
    - (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
    - (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
    - (3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
  - b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
    - (1) Stroke valves through outputs from the HMI/SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
    - (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
    - (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
- 3) Analog device testing:
  - a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
  - b) Apply provisional settings on controllers and alarm setpoints.
- 4) Analog input:
  - a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system.
    - (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
- 5) Analog output:
  - a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system.
    - (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
    - (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.



- 6) Submit completed test forms.
  - a) Discrete instrument input devices:
    - (1) Switch setting, contact action, and dead band.
    - (2) Valve position switches:
      - (a) Response in the PLC as the valve is stroked from the PLC.
      - (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
    - (3) Operator interface switches (control stations and other pilot devices) and associated response.
    - (4) Starter and drive auxiliary device contact response.
    - (5) Response of all other discrete inputs to the PLC.
    - (6) Test equipment used and associated serial numbers.
  - b) Discrete output devices:
    - (1) Observed response of field device to the discrete output from the PLC.
    - (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
    - (3) Test equipment used and associated serial numbers.
  - c) Analog input devices:
    - (1) Calibration range.
    - (2) Calibration data: Input, output, and error at each test value.
    - (3) Analog input associated PLC register address.
    - (4) Value in PLC register at each test point.
    - (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
    - (6) Test equipment used and associated serial numbers.
  - d) Analog output devices:
    - (1) Calibration range.
    - (2) Test value at each test point.
    - (3) Analog output associated PLC register address.
    - (4) Control variable value at field device at each test point.
    - (5) Physical device response at each test point:
      - (a) Response to be actual valve position, or motor speed, etc.
    - (6) Test equipment used and associated serial numbers.
- 7) Failure testing:
  - a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
    - (1) Equipment failure.
    - (2) Communications sub-system error.
    - (3) Power failure.
    - (4) Process equipment failure.
    - (5) High system loading conditions.
- 8) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.



4. Functional testing:

a. General:

- 1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
- 2) Performed by Contractor, ICSC, manufacturer's representative together, with assistance from the OWNER or the inspection staff, as needed.
- 3) Additional tests are specified in other Instrumentation and Control Sections.
- 4) Follow approved detailed test procedures and check lists for Functional Test activities.

b. Control logic operational validation:

- 1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
- 2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
- 3) Test in detail on a function-by-function and sentence-by-sentence basis.
- 4) Thoroughly test hardware and software functions:
- 5) Including all hardwired and software control circuit interlocks and alarms.
- 6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
- 7) Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.

c. Loop tuning:

- 1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
- 2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
- 3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
- 4) Functional validation sheets:





- a) Document each Functional test on an approved test form.
  - b) Document loop tuning with a report for each loop, including two-open chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
  - c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
    - (1) Loop number and P&ID number.
    - (2) Control strategy, or reference to specification tested.
    - (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
  - d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
    - (1) Specification page and paragraph of function demonstrated.
    - (2) Description of function and/or text from specification.
    - (3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
- 5) Functional certification:
- a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
    - (1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.
- C. Process Start-up Phase:
- 1. Process Start-up:
    - a. ICSC shall be onsite to support Process Start-up activities and provide functional changes as required.
  - 2. Process Operation Period:
    - a. ICSC shall be available to support Process Operational Period and provide functional changes as required.
  - 3. PCIS Optimization and Fine-Tuning:
    - a. General:
      - 1) After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
      - 2) This is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
      - 3) The complete PLC control and HMI/SCADA system must run continuously for the duration of the PCIS Optimization and Fine-Tuning.
      - 4) Test and use the entire process control system under standard operating conditions.
      - 5) Exercise all system functions.





- 6) Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
  - a) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the PCIS Optimization and Fine-Tuning until final acceptance of the system.
    - (1) Response time to the Project Site: 24 hours or less, for a major failure.
  - b. SCADA system testing:
    - 1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
    - 2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
      - a) Corrective action is required before restarting the PCIS Optimization and Fine-Tuning.
    - 3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
    - 4) Failures:
      - a) Classify failures as either major or minor:
        - (1) Minor failure:
          - (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
          - (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
          - (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
          - (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
        - (2) Major failure:
          - (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
          - (b) Cause termination of the PCIS Optimization and Fine-Tuning.
          - (c) Start a new acceptance test when the causes of a major failure have been corrected.



- (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
- 5) Technician report:
  - a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
  - b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
  - c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
  - d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

### **3.07 FIELD QUALITY CONTROL (NOT USED)**

### **3.01 RE-INSTALLATION (NOT USED)**

### **3.02 ADJUSTING (NOT USED)**

### **3.03 CLEANING (NOT USED)**

### **3.04 PROTECTION (NOT USED)**

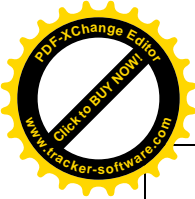
### **3.05 SCHEDULES**

- A. Example test forms:
  - 1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
  - 2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION



FACTORY ACCEPTANCE TEST - CONTROL PANELS	
<b>1. GENERAL INSPECTION</b>	
<b>A. Structural Inspection</b>	
<input type="checkbox"/> Verify Lifting Lugs Installed	
<input type="checkbox"/> Verify enclosure has lock and lock is functional	
<input type="checkbox"/> Confirm that seismic bracing components are provided per manufacturer's installation instructions	
<b>B. Exterior Inspection</b>	
<input type="checkbox"/> Cabinet exterior is clean, scratch, and dent free	
<input type="checkbox"/> Inspect externally for corrosion and damage	
<input type="checkbox"/> Verify enclosure door opens and closes easily	
<input type="checkbox"/> Verify enclosure has a 3-point latch	
<input type="checkbox"/> Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)	
<input type="checkbox"/> Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.)	
<input type="checkbox"/> Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)	
<b>Nameplates</b>	
<input type="checkbox"/> Cabinet has identification nameplate	
<input type="checkbox"/> All door labels are straight, spelled correctly, and match the tagging defined in the Contract	
<input type="checkbox"/> Cabinet has a nameplate that includes the following:	
<input type="checkbox"/> Power source(s)	<input type="checkbox"/> Integrator's Logo
<input type="checkbox"/> Circuit ID(s)	<input type="checkbox"/> Short Circuit KAIC ratings
<input type="checkbox"/> If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)	
<b>Door Devices</b>	
<input type="checkbox"/> All devices penetrating the outside of panel have gaskets, silicone or both	
<input type="checkbox"/> All door devices are installed (HMIs, Pilot Devices, etc.)	
<input type="checkbox"/> Door mounted equipment is mounted straight and square	
<input type="checkbox"/> All exterior or door mounted equipment present and accounted for, installed and securely fastened	
<input type="checkbox"/> NEMA classification has not been violated due to penetrations	
<input type="checkbox"/> Door mounted equipment has the same NEMA rating as the panel	
<input type="checkbox"/> All door mounted equipment installed at the correct height	
<input type="checkbox"/> All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)	
<input type="checkbox"/> Doors with multiple penetrations have adequate bracing (if needed)	
<input type="checkbox"/> Visually check condition of indicators , controllers and annunciators	
<input type="checkbox"/> Check that pilot lights illuminate correctly	
<input type="checkbox"/> Check the Push-To-Test function	
<input type="checkbox"/> Ensure correct pilot light color	
<b>Peripheral Devices</b>	
<input type="checkbox"/> Horn / Beacon is installed (where required)	
<input type="checkbox"/> Silence and Reset pushbutton	
PROJECT NAME: _____	
FACILITY NAME: _____	
PROCESS AREA: _____	
NETWORK ID: _____	
WITNESSED BY: _____	
TEST DATE: _____	
TESTED BY: _____	
COMPANY: _____	
PAGE: _____	
SIGNATURE: _____	



FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>1. GENERAL INSPECTION (continued)</b></p> <p><b>C. Interior Inspection</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Cabinet is cleaned of marks and dirt.</li><li><input type="checkbox"/> Inspect internally for corrosion and damage.</li><li><input type="checkbox"/> Back panel is clean of marks and dirt.</li><li><input type="checkbox"/> Interior of panel vacuumed and shall be free of all debris.</li><li><input type="checkbox"/> Check that the panel roof is clean and clear of foreign materials.</li><li><input type="checkbox"/> Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.</li><li><input type="checkbox"/> If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.</li><li><input type="checkbox"/> Check that a document pocket has been provided.</li><li><input type="checkbox"/> Intrusion alarms (where required).</li></ul> <p><b>Interior Labeling</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.</li><li><input type="checkbox"/> Verify that door mounted components are mounted square and symmetrical.</li><li><input type="checkbox"/> Verify that nameplates are straight, legible, and spelled correctly.</li><li><input type="checkbox"/> All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.</li><li><input type="checkbox"/> All wiring shrink labeled and or phased correctly to the specifications.</li><li><input type="checkbox"/> All wire labels shrunk completely rotated and aligned alike for easy identification.</li><li><input type="checkbox"/> All fuses and circuit breakers are labeled with ID and current rating.</li><li><input type="checkbox"/> System Integrator's label or labels installed on door.</li><li><input type="checkbox"/> Panel manufacturer model/serial number tag is present.</li><li><input type="checkbox"/> All required safety/warning tags installed and straight.</li><li><input type="checkbox"/> Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).</li></ul> <p><b>Wireways</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Plastic wire way covers installed properly.</li><li><input type="checkbox"/> Plastic wireways have no sharp edges.</li><li><input type="checkbox"/> No wire Ties inside the wireways.</li><li><input type="checkbox"/> No sharp edges on wire ties.</li><li><input type="checkbox"/> Separation: White duct is used for DC voltages, Gray duct is used for AC voltages.</li><li><input type="checkbox"/> Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.</li></ul>											
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FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>1. GENERAL INSPECTION (continued)</b></p> <p><b>C. Interior Inspection (continued)</b></p> <p><b>Wiring</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Visually check terminals and condition of internal wirings</li><li><input type="checkbox"/> Verify that the control panel has been assembled and wired as designed</li><li><input type="checkbox"/> Verify that all components are operational and perform the functions intended</li><li><input type="checkbox"/> Verify that all components are sized appropriately for the application</li><li><input type="checkbox"/> Verify that equipment control circuits function as intended</li><li><input type="checkbox"/> Back of door wiring is labeled and neatly formed</li><li><input type="checkbox"/> Back panel to door wiring has sufficient bending radius with spiral wrap</li><li><input type="checkbox"/> Wire connection has been verified wired to correct points within the panel</li><li><input type="checkbox"/> Individual wires have been given a pull test to verify a good terminal connection</li><li><input type="checkbox"/> Wire and cable minimum bending radius have not been violated</li><li><input type="checkbox"/> All equipment installed straight and square to back panel</li><li><input type="checkbox"/> Wire colors are correct:<ul style="list-style-type: none"><li><input type="checkbox"/> Black and White &gt; AC hot and neutral, respectively</li><li><input type="checkbox"/> Red &gt; AC control signals</li><li><input type="checkbox"/> Blue &gt; DC power and control (Blue w/White stripe for DC ground)</li><li><input type="checkbox"/> Yellow &gt; Foreign voltages (those still present when panel power is disconnected)</li><li><input type="checkbox"/> Green &gt; AC equipment ground</li><li><input type="checkbox"/> Black &gt; TSP (+)</li><li><input type="checkbox"/> White&gt; TSP(-)</li></ul></li><li><input type="checkbox"/> Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)</li><li><input type="checkbox"/> Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself</li><li><input type="checkbox"/> Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis</li><li><input type="checkbox"/> Intrinsic Safety Wiring<ul style="list-style-type: none"><li><input type="checkbox"/> Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring</li></ul></li><li><input type="checkbox"/> Verify all spare terminals are installed according to the percentage listed in the specifications</li></ul> <p><b>Grounding</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Equipped with "Blackburn" or other grounding type lug</li><li><input type="checkbox"/> Lug is securely fastened to the panel structure</li><li><input type="checkbox"/> Verify Grounding bar is installed</li><li><input type="checkbox"/> Verify Isolated ground bar is installed</li></ul>											
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FACTORY ACCEPTANCE TEST - CONTROL PANELS	
<b>2. POWER TEST</b>	
<b>A. AC Power</b>	
<input type="checkbox"/> AC Power is routed correctly within the panel, and is isolated from DC and network wiring.	
<input type="checkbox"/> All fuses are installed and sized properly.	
<input type="checkbox"/> All breakers are installed and sized properly.	
<input type="checkbox"/> 24 VDC Power Supplies are functional.	
<input type="checkbox"/> 24 VDC Power fail contacts are functional.	
<input type="checkbox"/> 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies. <input type="checkbox"/> 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.	
<input type="checkbox"/> Dedicated receptacle is wired to receive a dedicated AC supply.	
<input type="checkbox"/> Verify continuity for all DC commons, ground and AC neutrals.	
<input type="checkbox"/> Verify that the CP temporary input power is connected correctly and is the correct voltage.	
<input type="checkbox"/> Close the CP main circuit breaker(s).	
<input type="checkbox"/> Verify that voltages at subsequent circuit breakers are correct.	
<input type="checkbox"/> Close circuit breakers.	
<input type="checkbox"/> Verify that power feeding interruptible and uninterruptible power supplies is correct.	
<input type="checkbox"/> Turn on power supplies if they are not already on.	
<input type="checkbox"/> Verify that voltages at distribution terminals are correct.	
<input type="checkbox"/> Energize any remaining hardware such as the PLC.	
<b>B. Uninterruptible Power Supply (UPS)</b>	
<input type="checkbox"/> Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.	
<input type="checkbox"/> Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).	
<input type="checkbox"/> Test all UPS alarms (on inverter, failure, battery failure etc.)	
<input type="checkbox"/> Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.	
<b>3. CONTROLS &amp; AUXILIARY DEVICES TEST</b>	
<input type="checkbox"/> Verify all interposing and auxiliary relays are functioning.	
<input type="checkbox"/> Verify panel lights are functioning.	
<b>Ventilation and Heating</b>	
<input type="checkbox"/> If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.	
<input type="checkbox"/> Verify components are installed in the correct orientation for proper air flow.	
<b>4. HARDWIRED INTERLOCK AND SAFETY TEST</b>	
<input type="checkbox"/> Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.	
<input type="checkbox"/> Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.	
PROJECT NAME: _____ TEST DATE: _____	
FACILITY NAME: _____ TESTED BY: _____	
PROCESS AREA: _____ COMPANY: _____	
NETWORK ID: _____ PAGE: _____	
WITNESSED BY: _____ SIGNATURE: _____	



FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>5. PLC TEST</b></p> <p><b>A. Components</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.</li><li><input type="checkbox"/> Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.</li><li><input type="checkbox"/> TVSS is installed across the main incoming 120 VAC.</li></ul> <p><b>PLC and PLC Rack</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Verify all cards are securely seated.</li><li><input type="checkbox"/> Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations.</li></ul> <p><b>B. PLC I/O Test</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Furnish <b>I/O test forms</b> and test all the listed input and output points as follows:<ul style="list-style-type: none"><li><input type="checkbox"/> Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software.</li><li><input type="checkbox"/> Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting.</li><li><input type="checkbox"/> Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.</li><li><input type="checkbox"/> Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.</li></ul></li></ul> <p><b>C. Redundant Controllers (where required) Test</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Remove Communication cable from primary PLC to verify switching to backup PLC</li><li><input type="checkbox"/> Remove Communication cable from backup PLC to verify switching back to primary PLC</li><li><input type="checkbox"/> Remove Power cable from primary PLC to verify switching to backup PLC</li><li><input type="checkbox"/> Remove Power cable from backup PLC to verify switching back to primary PLC</li></ul> <p><b>D. PLC Control Logic Verification</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.<ul style="list-style-type: none"><li><input type="checkbox"/></li><li><input type="checkbox"/> DI states are either simulated by hardwired switches or forced inputs using a programming terminal.</li><li><input type="checkbox"/> For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.</li></ul></li></ul>											
<table style="width: 100%; border: none;"><tr><td style="width: 50%; border: none;">PROJECT NAME: _____</td><td style="width: 50%; border: none;">TEST DATE: _____</td></tr><tr><td style="border: none;">FACILITY NAME: _____</td><td style="border: none;">TESTED BY: _____</td></tr><tr><td style="border: none;">PROCESS AREA: _____</td><td style="border: none;">COMPANY: _____</td></tr><tr><td style="border: none;">NETWORK ID: _____</td><td style="border: none;">PAGE: _____</td></tr><tr><td style="border: none;">WITNESSED BY: _____</td><td style="border: none;">SIGNATURE: _____</td></tr></table>		PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
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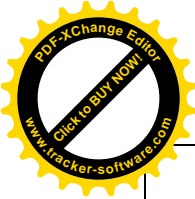


FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<p><b>5. PLC TEST (continued)</b></p> <p><b>D. PLC Control Logic Verification (continued)</b></p> <p><b>Typical Fault Logic</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.</li><li><input type="checkbox"/> The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.</li></ul> <p><b>Typical Fail to Start Logic</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.</li></ul>											
<p><b>6. HMI OR OIT TEST</b></p> <p><b>HMI / OIT Functionality</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Communication with PLC</li><li><input type="checkbox"/> Screen Layouts</li><li><input type="checkbox"/> Screen Navigation</li><li><input type="checkbox"/> Set Point Entry</li><li><input type="checkbox"/> Animation</li><li><input type="checkbox"/> Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)</li><li><input type="checkbox"/> Alarms</li><li><input type="checkbox"/> Acknowledge and Reset</li><li><input type="checkbox"/> Security / Access Levels / Passwords</li></ul>											
<p><b>7. NETWORK COMMUNICATION TEST</b></p> <p><b>A. Network Components</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Fiber optic cabling terminates in a patch panel</li><li><input type="checkbox"/> Media converters are installed and functional</li><li><input type="checkbox"/> Terminating resistors have been installed for trunk/tap topologies or where required</li><li><input type="checkbox"/> Wire and cable bending limitations have not been violated</li></ul> <p><b>B. Networking Functions</b></p> <ul style="list-style-type: none"><li><input type="checkbox"/> Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams</li><li><input type="checkbox"/> Verify network traffic rate and error margin is acceptable</li></ul>											
<table><tr><td>PROJECT NAME: _____</td><td>TEST DATE: _____</td></tr><tr><td>FACILITY NAME: _____</td><td>TESTED BY: _____</td></tr><tr><td>PROCESS AREA: _____</td><td>COMPANY: _____</td></tr><tr><td>NETWORK ID: _____</td><td>PAGE: _____</td></tr><tr><td>WITNESSED BY: _____</td><td>SIGNATURE: _____</td></tr></table>		PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
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FACTORY ACCEPTANCE TEST - CONTROL PANELS											
<b>8. FAT DOCUMENTATION AND RECORD</b> <b>Panel Documentation</b> <ul style="list-style-type: none"><li><input type="checkbox"/> As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.</li><li><input type="checkbox"/> Panel schematic and interconnection drawings.</li><li><input type="checkbox"/> P&amp;ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.</li><li><input type="checkbox"/> I/O list test forms of the process area to be tested.</li><li><input type="checkbox"/> FAT procedure of the process area to be tested.</li><li><input type="checkbox"/> Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.</li><li><input type="checkbox"/> Hard copy of the PLC application program of the process area to be tested.</li><li><input type="checkbox"/> Hard copy of the HMI/OIT graphic screens of the process area to be tested.</li></ul>											
<b>9. FAT TOOLS AND SOFTWARE</b> <ul style="list-style-type: none"><li><input type="checkbox"/> Simulation software if required</li><li><input type="checkbox"/> Digital volt meter Fluke 87</li><li><input type="checkbox"/> Process meter Fluke 787</li><li><input type="checkbox"/> Laptop computer with PLC application program</li><li><input type="checkbox"/> Temporary SCADA computer with HMI software and applicable graphic screens</li><li><input type="checkbox"/> Jumper wires</li></ul>											
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	<b>INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION</b>	
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INSTRUMENT LOOP NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

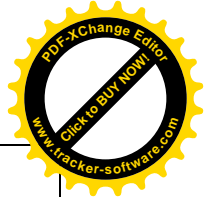
REMARKS: \_\_\_\_\_

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CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
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SIGNATURE _____	SIGNATURE _____
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DATE _____	DATE _____
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	<b>SWITCHES INSTALLATION AND CALIBRATION CHECKLIST</b>	
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INSTRUMENT LOOP NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ VERIFIED PER P&ID NO. \_\_\_\_\_
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_
- ☐ INSTALLATION CORRECT PER DETAIL NO. \_\_\_\_\_
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

FIELD CALIBRATION CHECK						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS	
1	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
2	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
3	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
4	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE



	<p align="center"><b>SWITCHES</b></p> <p align="center"><b>INSTALLATION AND CALIBRATION CHECKLIST</b></p>	
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CHECKED BY (COMPANY) \_\_\_\_\_

SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_



	<b>TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST</b>	
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INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

☐ No ☐ Yes

INSTRUMENT TYPE  
INDICATOR

☐ TRANSMITTER ☐ CONTROLLER ☐  
☐ OTHER

DESCRIPTION \_\_\_\_\_

INSTRUMENT TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

SERVICE  
DESCRIPTION \_\_\_\_\_

**BENCH CALIBRATION CHECK**

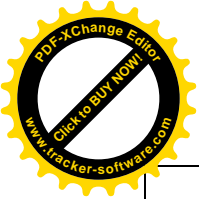
INPUT RANGE = _____		OUTPUT RANGE = _____		
HEAD CORRECTION = _____		<input type="checkbox"/> LINEAR		
CALIBRATED SPAN = _____		<input type="checkbox"/> SQUARE ROOT		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ VERIFIED PER P&ID NO. \_\_\_\_\_
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_
- ☐ INSTALLATION CORRECT PER DETAIL NO. \_\_\_\_\_
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

**FIELD CALIBRATION CHECK**

INPUT RANGE = _____		OUTPUT RANGE = _____		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				



	<b>TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST</b>	
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- ☐ DIRECT                      ☐ REVERSE
- ☐ ACTION VERIFIED AT 50% SPAN
- ☐ ACTION VERIFIED AT \_\_\_\_\_ SPAN

CONTROLLER SETTINGS								
SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS \_\_\_\_\_

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\_\_\_\_\_

CHECKED BY (COMPANY) \_\_\_\_\_ ACCEPTED BY  
(COMPANY) \_\_\_\_\_

SIGNATURE \_\_\_\_\_ SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_ DATE \_\_\_\_\_



	<b>ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST</b>	
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INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

TYPE OF INSTRUMENT \_\_\_\_\_

INSTRUMENT TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

CHECK BELOW, IF TRUE

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ VERIFIED PER P&ID NO. \_\_\_\_\_
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_
- ☐ INSTALLATION CORRECT PER DETAIL NO. \_\_\_\_\_
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS \_\_\_\_\_

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CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____



	<b>CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST</b>	
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☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

☐ VALVE TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ TRANSDUCER TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ SOLENOID TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ VOLUME BOOSTER TAG NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

☐ POSITIONER \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

SERVICE DESCRIPTION \_\_\_\_\_

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE \_\_\_\_\_

☐ VERIFIED PER P&ID NO. \_\_\_\_\_

☐ CORRESPONDS TO SPECIFICATION SHEET NO. \_\_\_\_\_

☐ VALVE SPECIFICATION NO. \_\_\_\_\_

☐ TRANSDUCER SPECIFICATION NO. \_\_\_\_\_

☐ SOLENOID SPECIFICATION NO. \_\_\_\_\_

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. \_\_\_\_\_

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS \_\_\_\_\_

☐ VALVE DETAIL NO. \_\_\_\_\_

☐ TRANSDUCER DETAIL NO. \_\_\_\_\_

☐ SOLENOID DETAIL NO. \_\_\_\_\_





	<b>CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST</b>	
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- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	<input type="checkbox"/> PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS		ON LOSS OF POWER SOLENOID FAILS
	<input type="checkbox"/> OPEN <input type="checkbox"/> CLOSE	<input type="checkbox"/> TO VENT <input type="checkbox"/> TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
	<input type="checkbox"/> ON BENCH <input type="checkbox"/> IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS \_\_\_\_\_

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CHECKED BY (COMPANY) \_\_\_\_\_ ACCEPTED BY (COMPANY) \_\_\_\_\_

SIGNATURE \_\_\_\_\_ SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_ DATE \_\_\_\_\_



DEVICENET INSTALLATION TESTING	
DeviceNet Network _____	
<b>Network Installation Characteristics</b>	
<u>Architecture</u>	<u>Baud Rate</u>
<input type="checkbox"/> Single Master or <input type="checkbox"/> Multi Master <input type="checkbox"/> Redundant Power Supplies <input type="checkbox"/> Per Network	<input type="checkbox"/> 125 kBaud <input type="checkbox"/> 250 kBaud <input type="checkbox"/> 500 kBaud
<u>Trunk Media</u>	<u>Drop Media</u>
<input type="checkbox"/> Thick Round <input type="checkbox"/> Thin Round	<input type="checkbox"/> Thick Round, Unshielded <input type="checkbox"/> Thin Round, Shielded <input type="checkbox"/> Thick Round, Shielded
<u>Installed Node List</u>	
<input type="checkbox"/> 0 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> 8 <input type="checkbox"/> 9 <input type="checkbox"/> 10 <input type="checkbox"/> 11 <input type="checkbox"/> 12 <input type="checkbox"/> 13 <input type="checkbox"/> 14 <input type="checkbox"/> 15 <input type="checkbox"/> 16 <input type="checkbox"/> 17 <input type="checkbox"/> 18 <input type="checkbox"/> 19 <input type="checkbox"/> 20 <input type="checkbox"/> 21 <input type="checkbox"/> 22 <input type="checkbox"/> 23 <input type="checkbox"/> 24 <input type="checkbox"/> 25 <input type="checkbox"/> 26 <input type="checkbox"/> 27 <input type="checkbox"/> 28 <input type="checkbox"/> 29 <input type="checkbox"/> 30 <input type="checkbox"/> 31 <input type="checkbox"/> 32 <input type="checkbox"/> 33 <input type="checkbox"/> 34 <input type="checkbox"/> 35 <input type="checkbox"/> 36 <input type="checkbox"/> 37 <input type="checkbox"/> 38 <input type="checkbox"/> 39 <input type="checkbox"/> 40 <input type="checkbox"/> 41 <input type="checkbox"/> 42 <input type="checkbox"/> 43 <input type="checkbox"/> 44 <input type="checkbox"/> 45 <input type="checkbox"/> 46 <input type="checkbox"/> 47 <input type="checkbox"/> 48 <input type="checkbox"/> 49 <input type="checkbox"/> 50 <input type="checkbox"/> 51 <input type="checkbox"/> 52 <input type="checkbox"/> 53 <input type="checkbox"/> 54 <input type="checkbox"/> 55 <input type="checkbox"/> 56 <input type="checkbox"/> 57 <input type="checkbox"/> 58 <input type="checkbox"/> 59 <input type="checkbox"/> 60 <input type="checkbox"/> 61 <input type="checkbox"/> 62 <input type="checkbox"/> 63	
<input type="checkbox"/> All nodes present and in accordance with network drawings/specifications <span style="float: right;"><input type="checkbox"/> ODVA approved devices</span>	
<input type="checkbox"/> Nodes/devices accessible for inspection and maintenance <span style="float: right;"><input type="checkbox"/> Nodes/devices properly addressed</span>	
Comments: _____ _____ _____	
<b>Media Inspection</b>	
<u>Trunk Cable</u>	<u>Drop Cable</u>
<input type="checkbox"/> ODVA approved <input type="checkbox"/> Labeling complete <input type="checkbox"/> Cable/conductor terminations <input type="checkbox"/> Terminating resistors at ends	<input type="checkbox"/> ODVA approved <input type="checkbox"/> Labeling complete <input type="checkbox"/> Cable/conductor terminations <input type="checkbox"/> Maximum drop length < 20'
<u>Installation</u>	
<input type="checkbox"/> No evidence of physical damage <input type="checkbox"/> Installed in protective raceway <input type="checkbox"/> Bending radius not exceeded  <input type="checkbox"/> Cable supports in place  <input type="checkbox"/> V- and shield are grounded <input type="checkbox"/> Clearance from high temperature/voltage sources <input type="checkbox"/> No installation subject to vibration	
Comments: _____ _____ _____	



### Network Power Supplies

#### Power Supply Equipment

- ☐ ODVA compliant
- ☐ Quantity and ratings

#### Supply Source (120 VAC)

- ☐ Overcurrent protection
- ☐ Conductor size

#### Network Power Tap (24 VDC)

- ☐ Overcurrent protection
- ☐ Conductor size

Comments:

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CHECKED BY (COMPANY)

ACCEPTED BY  
(COMPANY)

SIGNATURE

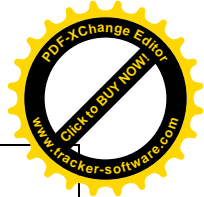
SIGNATURE

DATE

DATE



7190700 FCWRF Industrial EQ Basin Rehab 17950-34  
Little Rock Water Reclamation Authority



**PROFIBUS  
INSTALLATION QUALIFICATION AND TESTING**

**Media Inspection**

<b>CABLING</b>	<b>DP NETWORK</b>	<b>PA NETWORK SEGMENTS</b>																						
PI COMPLIANT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
LABELING COMPLETE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
GROUNDING	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
CABLE AND CONDUCTOR TERMINATIONS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
NO STUB LINES (DP ONLY)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
TERMINATING RESISTORS (IN PLACE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
DEDICATED DIAGNOSTICS BUS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
INSTALLATION																								
NO EVIDENCE OF PHYSICAL DAMAGE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
INSTALLATION IN PROTECTIVE RACEWAY	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
CLEARANCES FROM HIGH TEMPERATURE SOURCES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
CLEARANCES FROM HIGH VOLTAGE SOURCES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
BEND RADIUS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
NO INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																		
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)																								
<table border="1" style="width: 100%; height: 20px;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																								

**Device Inspection**

<b>DEVICE QUANTITY/TYPE</b>	<b>INSTALLATION</b>																		
<input type="checkbox"/> TOTAL SLAVE COUNT	<input type="checkbox"/> NO EVIDENCE OF PHYSICAL DAMAGE																		
<input type="checkbox"/> MOST UPDATED DEVICE DRIVER INSTALLED?	<input type="checkbox"/> ACCESSIBLE FOR INSPECTION AND MAINTENANCE																		
<input type="checkbox"/> INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS	<input type="checkbox"/> FDT COMPLIANT DEVICES																		
<input type="checkbox"/> PI COMPLIANCE DEVICES																			
<input type="checkbox"/> DIAGNOSTICS MODULE INSTALLED																			
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)																			
<table border="1" style="width: 100%; height: 20px;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																			

**Power Supplies**

<b>ACTIVE TERMINATIONS</b>	<b>COUPLERS</b>	<b>REPEATERS</b>																		
<input type="checkbox"/> SOURCE LOCATION	<input type="checkbox"/> SOURCE LOCATION	<input type="checkbox"/> SOURCE LOCATION																		
<input type="checkbox"/> OVERCURRENT PROTECTION	<input type="checkbox"/> OVERCURRENT PROTECTION	<input type="checkbox"/> OVERCURRENT PROTECTION																		
<input type="checkbox"/> CONDUCTOR SIZE	<input type="checkbox"/> CONDUCTOR SIZE	<input type="checkbox"/> CONDUCTOR SIZE																		
<input type="checkbox"/> GROUNDING	<input type="checkbox"/> GROUNDING	<input type="checkbox"/> GROUNDING																		
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)																				
<table border="1" style="width: 100%; height: 20px;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																				

PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____	SIGNATURE: _____



**PROFIBUS  
INSTALLATION QUALIFICATION AND TESTING**

**DP Network Media Testing**

DESCRIPTION	SEGMENT ID												
<b>TRUNK LENGTH (feet)</b>													
ALLOWABLE TRUNK LENGTH AT SPECIFIED DATA RATE:													
MEASURED TRUNK LENGTH:													
SPARE TRUNK LENGTH													
<b>RESISTANCE MEASUREMENTS (ohms)</b>													
NETWORK CABLE:													
NO TERMINATIONS													
ONE TERMINATION													
TWO TERMINATIONS													
<b>POWER SUPPLY VOLTAGE (volts DC)</b>													
ACTIVE TERMINATOR													
REPEATER CP1100-RPT1													
REPEATER CP1000-RPT1													
REPEATER CP1000-RPT2													
REPEATER CP2700-RPT1													
<b>CABLE TEXTS</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	<b>PASS</b>	<b>FAIL</b>	
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES AND SHIELD	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TESTED FOR SHIELD CONTINUITY	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TESTED FOR OPEN SIGNAL LINES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TESTED FOR CROSSED SIGNAL LINES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TESTED FOR CORRECT TERMINATOR POSITION	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CORRECT CABLE TYPE AND LENGTH	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TESTED FOR SECURE AND TIGHT CONNECTORS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)													
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PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____ SIGNATURE: _____	