BERKELEY COUNTY, SOUTH CAROLINA

CONTRACT DOCUMENTS FOR
CONSTRUCTION OF:

LOWER BERKELEY WWTP AERATION SYSTEM IMPROVEMENTS
SCDHEC CONSTRUCTION PERMIT No.: 41671-WW
BCWS BID No.: BCWS-23-19/20

ISSUED FOR CONSTRUCTION

April 2020

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Project No.: 30557-003

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GENERAL REQUIREMENTS

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SECTION 01010

SUMMARY OF WORK

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Work to be done under these Contracts and in accordance with these Specifications consists of furnishing all equipment, superintendence, labor, skill, material and all other items necessary for the construction of the Lower Berkeley WWTP Aeration System Improvements Project. The Contractor shall perform all work required for such construction in accordance with the Contract Documents and subject to the terms and conditions of the Contract, complete and ready for use.

B. The principal features of the Work to be performed under these Contracts includes:

Work may include, but is not limited to, the Civil, Structural, Mechanical and Electrical Improvements. Offerors must be able to provide all supervision, manpower, materials, equipment and supplies necessary to complete any scope of work outlined. The services to be provided shall include but not be limited to the following:

1. Site grading and asphalt paving.

2. Demolition of electrical equipment, piping, mechanical surface aeration rotors, and electrical cable.

3. Installation of a new manual bar screen in the primary clarifier by-pass channel.

4. Construction of a new blower facility including the installation of four (4) new blowers and associated air piping, fittings and valves.

5. Renovation of existing aeration tanks, including installation of new diffused air piping and diffusers, installation of eight (8) submersible mixers with access and support platforms, improvements to the existing elevated basin walkways, and baffle wall modifications.

6. Modification to the existing junction structure including replacement of the existing rotating weir assemblies with four (4) new static weirs, four (4) new modulating weir gates, and bypass sluice gates.

7. Construction and installation of equipment and building pads, (1) 3,000kW diesel generator system with fuel tank in a prefabricated enclosure, pre-manufactured electrical control buildings (Blower Electrical Control Building, Main Electrical Control Building), 27kV Class Switchgear, 35kV Class medium voltage cable replacement, low voltage electrical equipment and controls, including PLC, conduits, wiring, junction boxes, and grounding.

8. Installation and operation of temporary aerators and temporary by-pass pumping.

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C. The foregoing description(s) shall not be construed as a complete description of all work required.

1.02 CONTRACT DOCUMENTS

A. The Work to be done is shown on the set of Drawings entitled Lower Berkeley WWTP Aeration System Improvements project and Dated March 2019. The numbers and titles of all Drawings appear on the index sheet of the Drawings, Drawing G01. All drawings so enumerated shall be considered an integral part of the Contract Documents as defined herein.

B. Certain Document Sections refer to Divisions of the Contract Specifications. Sections are each individually numbered portions of the Specifications (numerically) such as 08110, 13182, 15206, etc. The term Division is used as a convenience term meaning all Sections within a numerical grouping. Division 16 would thus include Sections 16000 through 16902.

C. Where references in the Contract Documents are made to Contractors for specific disciplines of work (i.e. Electrical Contractor, etc.), these references shall be interpreted to be the single prime Contractor when the project is bid or awarded as a single prime contract.

1.03 GENERAL ARRANGEMENT

A. Drawings indicate the extent and general arrangement of the work. If any departures from the Drawings are deemed necessary by the Contractor to accommodate the materials and equipment he proposes to furnish, details of such departures and reasons therefore shall be submitted as soon as practicable to the Engineer for approval. No such departures shall be made without the prior written approval of the Engineer. Approved changes shall be made without additional cost to the Owner for this work or related work under other Contracts of the Project.

B. The specific equipment proposed for use by the Contractor on the project may require changes, in structures, auxiliary equipment, piping, electrical, mechanical, controls or other work to provide a complete satisfactory operating installation. The Contractor shall submit to the Engineer, for approval, all necessary Drawings and details showing such changes to verify conformance with the overall project structural and architectural requirements and overall project operating performance. The Bid Price shall include all costs in connection with the preparation of new drawings and details and all changes to construction work to accommodate the proposed equipment, including increases in the costs of other Contracts.

1.04 CONSTRUCTION PERMITS, EASEMENTS AND ENCROACHMENTS

A. The Owner shall obtain or cause to be obtained a right-of-way encroachment agreement from SCE&G. The Contractor shall verify that these agreements have been obtained and shall comply with the conditions set forth in each agreement.

B. The Contractor shall obtain, keep current and pay all fees for any necessary construction permits from those authorities, agencies, or municipalities having jurisdiction over land areas, utilities, or structures which are located within the Contract limits and which will be occupied, encountered, used, or temporarily interrupted by the Contractor's operations unless otherwise stated. Record copies of all permits shall be furnished to the Engineer.

C. When construction permits are accompanied by regulations or requirements issued by a particular authority, agency or municipality, it shall be the Contractor's responsibility to familiarize himself and comply with such regulations or requirements as they apply to his operations on this Project.

D. The Contractor shall provide any required Performance and Indemnity Bond(s) and any additional specific insurance coverage required of the Owner by the Encroachment Agreement(s) in accordance with the Encroachment Agreement(s) between the Owner and the South Carolina Department of Transportation. The Contractor shall fully comply with all of the requirements of the Owner included in the Encroachment Agreement(s).

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1.05 ADDITIONAL ENGINEERING SERVICES

A. In the event that the Engineer is required to provide additional engineering services as a result of substitution of materials or equipment which are not "or equal" by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Engineer is required to examine and evaluate any changes proposed by the Contractor for the convenience of the Contractor, then the Engineer's charges in connection with such additional services shall be charged to the Contractor by the Owner.

B. Structural design shown on the Contract Drawings is based upon typical weights for major items of equipment as indicated on the Contract Drawings and specified. If the equipment furnished exceeds the weights of said equipment, the Contractor shall assume the responsibility for all costs of redesign and for any construction changes required to accommodate the equipment furnished, including the Engineer's expenses in connection therewith.

C. In the event that the Engineer is required to provide additional engineering services as a result of Contractor's errors, omissions, or failure to conform to the requirements of the Contract Documents, or if the Engineer is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Engineer's charges in connection with such additional services shall be charged to the Contractor by the Owner.

1.06 ADDITIONAL OWNER'S EXPENSES

A. In the event the Work of this Contract is not completed within the time set forth in the Contract or within the time to which such completion may have been extended in accordance with the Contract Documents, the additional engineering or inspection charges incurred by the Owner may be charged to the Contractor and deducted from the monies due him. Extra work or supplemental Contract work added to the original Contract, as well as extenuating circumstances beyond the control of the Contractor, will be given due

consideration by the Owner before assessing engineering and inspection charges against the Contractor.

B. Unless otherwise specifically permitted, the normal time of work under this Contract is limited to 8 hours per day, Monday through Friday. Work beyond these hours will result in additional expense to the Owner. Any expenses and/or damages, including the cost of the Engineer's on site personnel, arising from the Contractor's operations beyond the hours and days specified above shall be borne by the Contractor.

C. Charges assessed to the Contractor for additional engineering and inspection costs will be determined based on actual hours charged to the job by the Engineer. Daily rates will depend on the number and classifications of employees involved, but in no case shall such charges exceed $500 per day for field personnel and $650 per day for engineering personnel, based on an eight hour workday.

D. Charges for additional Owner's expenses shall be in addition to any liquidated damages assessed in accordance with the Contract.

1.07 TIME OF WORK

A. The normal time of work for this Contract is limited to 40 hours per week and shall generally be between the hours of 7:00 a.m. and 6:00 p.m., Monday through Friday. The Contractor may elect to work beyond these hours or on weekends provided that all costs incurred by the Owner for additional engineering shall be borne by the Contractor.

1. The Owner shall deduct the cost of additional engineering costs from monies due the Contractor.

B. If it shall become imperative to perform work at night, the Owner and Engineer shall be informed a reasonable time in advance of the beginning of such work. Temporary lighting and all other necessary facilities for performing and inspecting the work shall be provided and maintained by the Contractor.

C. Unless otherwise specifically permitted, all work that would be subject to damage shall be stopped during inclement, stormy or freezing weather. Only such work as will not suffer injury to workmanship or materials will be permitted. Contractor shall carefully protect his work against damage or injury from the weather, and when work is permitted during freezing weather, he shall provide and maintain approved facilities for heating the materials and for protecting the finished work.

1.08 SUBSURFACE DATA

A. Subsurface data are offered in good faith solely for placing the Bidder in receipt of all information available to the Owner and Engineer and in no event is to be considered as part of the Contract Documents.

B. The Bidder must interpret such subsurface data according to his own judgment and acknowledge that he is not relying upon the same as accurately describing the subsurface conditions, which may be found to exist.

1. The test boring logs present factual information of the subsurface conditions at the specific test boring location only. The Bidder should not consider, or conclude, that the subsurface conditions will be consistent between test boring locations.

C. The Bidder further acknowledges that he assumes all risks contingent upon the nature of the sub-surface conditions to be actually encountered by him in performing the work covered by the Contract, even though such actual conditions may result in the Bidder performing more or less work than he originally anticipated.

D. The Bidder is further advised that the Owner has made sub-surface investigations and a report has been prepared, in connection with this project for the Engineer, a copy of which is appended to the rear of these specifications.

E. In making this data available, the Owner makes no guarantee, either expressed or implied, as to their accuracy or to the accuracy of any interpretation thereof.

1.09 SURVEYS AND LAYOUT

A. All work under this Contract shall be constructed in accordance with the lines and grades shown on the Drawings or as directed by the Engineer. Elevation of existing ground and appurtenances are believed to be reasonably correct 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 accomplishing the stake out survey shall be referred immediately to the Engineer for interpretation or correction.

B. All survey work for construction control purposes shall be made by the Contractor at his expense. The Contractor shall provide a Licensed Surveyor as Chief of Party, competently qualified men, all necessary instruments, stakes, and other material to perform the work.

C. Contractor shall establish all baselines for the location of the principal component parts of the work together with a suitable number of bench marks and batter boards adjacent to the work. Based upon the information provided by the Contract Drawings, the Contractor shall develop and make all detail surveys necessary for construction, including slope stakes, batter boards, stakes for all working points, lines and elevations.

D. Contractor shall have the responsibility to carefully preserve the bench marks, reference points and stakes, and in the case of destruction thereof by the Contractor or resulting from his negligence, the Contractor shall be charged with the expense and damage resulting therefrom and shall be responsible for any mistakes that may be caused by the unnecessary loss or disturbance of such bench marks, reference points and stakes.

E. Existing or new control points, property markers and monuments that will be or are destroyed during the normal causes of construction shall be reestablished by the Contractor and all reference ties recorded therefore shall be furnished to the Engineer. All computations necessary to establish the exact position of the work shall be made and preserved by the Contractor.

F. The Engineer may check all or any portion of the work and the Contractor shall afford all necessary assistance to the Engineer in carrying out such checks. Any necessary corrections to the work shall be immediately made by the Contractor. Such checking by the Engineer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of his work.

G. At completion of the work, the Contractor shall furnish Record Drawings indicating the final layout of all structures, roads, all structures, existing bench marks, etc. The Record Drawings shall indicate all critical elevations of piping, structures, finish grades, etc.

H. Contractor shall have all weirs surveyed by a licensed land surveyor and adjusted to match specified elevations as shown on the Contract Drawings. Weirs shall be surveyed at no more than ten (10) feet spacing, but no less than 2 points shall be surveyed on each section of weir plate. Final elevations shall be set to within a tolerance of +/- 0.05 inches of specified elevation. If a greater tolerance is allowed, it will be noted on the Contract Drawings. A final report showing all specified and surveyed elevations shall be certified by the surveyor and delivered to the Engineer.

1.10 FIRE PROTECTION

A. Contractor shall take all necessary precautions to prevent fires at or adjacent to the work, buildings, etc., and shall provide adequate facilities for extinguishing fires which do occur. Burning, if permitted in Division 2, shall be limited to areas approved by the Engineer and Owner and properly controlled by the Contractor.

B. When fire or explosion hazards are created in the vicinity of the work as a result of the locations of fuel tanks, or similar hazardous utilities or devices, the Contractor shall immediately alert the local Fire Marshal, the Engineer, and the Owner of such tank or device. The Contractor shall exercise all safety precautions and shall comply with all instructions issued by the Fire Marshal and shall cooperate with the Owner of the tank or device to prevent the occurrence of fire or explosion.

1.11 CHEMICALS

A. All chemicals used during project construction or furnished for project operation, whether herbicide, pesticide, disinfectant, polymer, or reactant of other classification, must show approval of either the EPA or USDA. Use of all such chemicals and disposal of residues shall be in strict conformance with all applicable rules and regulations.

1.12 FIRST AID FACILITIES AND ACCIDENTS

A. First Aid Facilities

1. The Contractor shall provide at the site such equipment and facilities as are necessary to supply first aid to any of his personnel who may be injured in connection with the work.

B. Accidents

1. The Contractor shall promptly report, in writing, to the Engineer and Owner all accidents whatsoever out of, or in connection with, the performance of the work, whether on or adjacent to the site, which cause death, personal injury or property damage, giving full details and statements of witnesses.

2. If death, serious injuries, or serious damages are caused, the accident shall be reported immediately by telephone or messenger to both the Owner and the Engineer.

3. If any claim is made by anyone against the Contractor or a Subcontractor on account of any accidents, the Contractor shall promptly report the facts, in writing, to the Engineer and Owner, giving full details of the claim.

1.13 ULTIMATE DISPOSITION OF CLAIMS BY ONE CONTRACTOR ARISING FROM ALLEGED DAMAGE BY ANOTHER CONTRACTOR

A. During the progress of the work, other Contractors may be engaged in performing other work or may be awarded other Contracts for additional work on this project. In that event, the Contractor shall coordinate the work to be done hereunder with the work of such other Contractors and the Contractor shall fully cooperate with such other Contractors and carefully fit its own work to that provided under other Contracts as may be directed by the Engineer. The Contractor shall not commit or permit any act which will interfere with the performance of work by any other Contractor.

B. If the Engineer shall determine that the Contractor is failing to coordinate his work with the work of the other Contractors as the Engineer directed, then the Owner shall have the right to withhold any payments otherwise due hereunder until the Contractor completely complies with the Engineer's directions.

C. If the Contractor notifies the Engineer in writing that another Contractor is failing to coordinate his work with the work of this Contract as directed, the Engineer will promptly investigate the charge. If the Engineer finds it to be true, he will promptly issue such directions to the other Contractor with respect thereto as the situation may require. The Owner, the Engineer, nor any of their agents shall not, however, be liable for any damages suffered by the Contractor by reason of the other Contractor's failure to promptly comply with the directions so issued by the Engineer, or by reason of another Contractor's default in performance, it being understood that the Owner does not guarantee the responsibility or continued efficiency of any Contractor.

D. The Contractor shall indemnify and hold the Owner and the Engineer harmless from any and all claims of judgments for damages and from costs and expenses to which the Owner may be subjected or which it may suffer or incur by reason of the Contractor's failure to comply with the Engineer's directions promptly.

E. Should the Contractor sustain any damage through any act or omission of any other Contractor having a Contract with the Owner for the performance of work upon the site or of work which may be necessary to be performed for the proper execution of the work to be performed hereunder, or through any act or omission of a Subcontractor of such Contract, the Contractor shall have no claim against the Owner or the Engineer for such damage, but shall have a right to recover such damage from the other Contractor under the provision similar to the following provisions which have been or will be inserted in the Contracts with such other Contractors.

F. Should any other Contractor having or who shall hereafter have a Contract with the Owner for the performance of work upon the site sustain any damage through any act or omission of the Contractor hereunder or through any act or omission of any Subcontractor of the Contractor, the Contractor agrees to reimburse such other Contractor for all such damages and to defend at his own expense any suit based upon such claim and if any judgment or claims against the Owner shall be allowed, the Contractor shall pay or satisfy such judgment or claim and pay all costs and expenses in connection therewith and shall indemnify and hold the Owner harmless from all such claims.

G. The Owner's right to indemnification hereunder shall in no way be diminished, waived or discharged, by its recourse to assessment of liquidated damages as provided in the Contract, or by the exercise of any other remedy provided for by Contract Documents or by law.

1.14 BLASTING AND EXPLOSIVES

A. THE USE OF BLASTING OR EXPLOSIVES SHALL NOT BE ALLOWED UNDER THIS PROJECT.

1.15 LIMITS OF WORK AREA

A. The Contractor shall confine his construction operations within the Contract limits shown on the Drawings and/or property lines and/or fence lines. Storage of equipment and materials, or erection and use of sheds outside of the Contract limits, if such areas are the property of the Owner, shall be used only with the Owner's approval. Such storage or temporary structures, even within the Contract's limits, shall be confined to the Owner's property and shall not be placed on properties designated as easements or rights-of-way unless specifically permitted elsewhere in the Contract Documents.

1.16 WEATHER CONDITIONS

A. No work shall be done when the weather is unsuitable. The Contractor shall take necessary precautions (in the event of impending storms) to protect all work, materials, or equipment from damage or deterioration due to floods, driving rain, or wind, and snow storms. The Owner reserves the right, through the opinion of the Engineer, to order that additional protection measures over and beyond those proposed by the Contractor, be taken to safeguard all components of the Project. The Contractor shall not claim any compensation for such precautionary measures so ordered, nor claim any compensation from the Owner for damage to the work from weather elements.

B. The mixing and placing of concrete or pavement courses, the laying of masonry, and installation of sewers and water mains shall be stopped during rainstorms, if ordered by the Engineer; and all freshly placed work shall be protected by canvas or other suitable covering in such manner as to prevent running water from coming in contact with it. Sufficient coverings shall be provided and kept ready at hand for this purpose. The limitations and requirements for mixing and placing concrete, or laying of masonry, in cold weather shall be as described elsewhere in these Specifications.

1.17 PERIODIC CLEANUP: BASIC SITE RESTORATION

A. During construction, the Contractor shall regularly remove from the site of the work all accumulated debris and surplus materials of any kind which result from his operations. Unused equipment and tools shall be stored at the Contractor's yard or base of operations for the Project.

B. When the work involves installation of sewers, drains, water mains, manholes, underground structures, or other disturbance of existing features in or across streets, rights-of-way, easements, or private property, the Contractor shall (as the work progresses) promptly backfill, compact, grade, and otherwise restore the disturbed area to the basic condition which will permit resumption of pedestrian or vehicular traffic and any other critical activity or functions consistent with the original use of the land. The requirements for temporary paving of streets, walks, and driveways are specified elsewhere. Unsightly mounds of earth, large stones, boulders, and debris shall be removed so that the site presents a neat appearance.

C. The Contractor shall perform the cleanup work on a regular basis and as frequently as ordered by the Engineer. Basic site restoration in a particular area shall be accomplished immediately following the installation or completion of the required facilities in that area. Furthermore, such work shall also be accomplished, when ordered by the Engineer, if partially completed facilities must remain incomplete for some time period due to unforeseen circumstances.

D. Upon failure of the Contractor to perform periodic cleanup and basic restoration of the site to the Engineer's satisfaction, the Owner may, upon five (5) days prior written notice to the Contractor, without prejudice to any other rights or remedies of the Owner, cause such work for which the Contractor is responsible to be accomplished to the extent deemed necessary by the Engineer, and all costs resulting therefrom shall be charged to the Contractor and deducted from the amounts of money that may be due him.

1.18 USE OF FACILITIES BEFORE COMPLETION

A. The Owner reserves the right to enter and use any portion of the constructed facilities before final completion of the whole work to be done under this Contract. However, only those portions of the facilities which have been completed to the Engineer's satisfaction, as evidenced by his issuing a Certificate of Substantial Completion covering that part of the work, shall be placed in service.

B. It shall be the Owner's responsibility to prevent premature connections to or use of any portion of the installed facilities by private or public parties, persons or groups of persons, before the Engineer issues his Certificate of Substantial Completion covering that portion of the work to be placed in service.

C. Consistent with the approved progress schedule, the Contractor shall cooperate with the Owner, his agents, and the Engineer to accelerate completion of those facilities, or portions thereof, which have been designated for early use by the Owner.

1.19 CONSTRUCTION VIDEO

A. The Contractor shall video the entire project site including all concrete and asphalt pavements, curb and gutter, fencing to remain, structures to be demolished, and existing structures that are to be modified. The original video image shall be turned over to the Engineer prior to beginning construction activities. The video shall be provided as an Audio Video Interleave File (.avi) and shall be provided on DVD+R/DVD-ROM compatible media only. The video shall clearly identify existing site and structural conditions prior to construction.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01025

MEASUREMENT AND PAYMENT

PART 1 -- GENERAL

1.01 SCOPE OF WORK

A. The items listed below, beginning with 1.03 GENERAL CONSTRUCTION, refer to and are the same pay items listed in the Bid Form Table. They constitute all of the pay items for the completion of the Work. No direct or separate payment will be made for providing miscellaneous temporary or accessory works, services, layout surveys, job signs, sanitary requirements, safety devices, approval and record drawings, water supplies, power, maintaining traffic, removal of waste, watchmen, and other requirements of the General Conditions, Supplementary Conditions, Special Conditions, Instructions to Bidders, and the General Requirements. Compensation for all such services, things and materials shall be included in the prices stipulated for the lump sum and unit price pay items listed herein.

B. Each lump sum and unit bid price will be deemed to include an amount considered by the Contractor to be adequate to cover the Contractor's overhead and profit for each separately identified item.

1.02 ENGINEER'S ESTIMATE OF QUANTITIES

A. The Engineer's estimated quantities for unit price pay items, as listed in the Bid Form Table, are approximate and are included solely for the purpose of comparison of Bids. The Owner does not expressly or by implication agree that the nature of the Work encountered or the actual quantities of material required will correspond therewith and reserves the right to increase or decrease any quantity or to eliminate any quantity as the Owner may deem necessary.

1.03 GENERAL CONSTRUCTION

A. Lump Sum Pay Item (Bid Item No. 1)

1. Lump Sum for All Construction Work not Otherwise Included in the Unit Price Items.

Measurement and Payment: The lump sum payment will be full compensation for completing all work (including all permitting costs), as shown on the Drawings and specified in the Bidding and Contract Requirements and under Divisions 1 through 17, not otherwise included in unit price items.

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B. Unit Price Pay Items (Bid Item No. 2)

1. Removal, Decanting, Hauling, and Disposal of Materials to Subtitle D Landfill

Measurement: Existing facilities (tanks, wells, manholes, piping, etc.) shall be cleaned out prior to performing interior modifications or structure demolition as designated on the Drawings. The following materials shall be removed from existing facilities, decanted of excess water, hauled, and disposed by the Contractor at a Subtitle D landfill:

- Residual material from all plant facilities including but not limited to miscellaneous manholes and piping, Aeration Tank Nos. 1 and 2, Junction Structure, etc. Residual material will include grit, rags, trash, etc.; and will be of varying, undesignated depths and quantities in facilities or portions of facilities.

These materials will be measured based on cubic yards of fully loaded trucks, or portions thereof if not fully loaded. Measurement will occur after the material has been sufficiently decanted for acceptance at a Subtitle D landfill.

Payment: All costs associated with removal of materials from existing facilities, decanting excess water into owner-designated facilities on the plant site, hauling of materials to a Subtitle D landfill, disposal of materials at landfill including tipping fees, and all labor, materials, equipment, incidentals, permits, etc. associated with work shall be paid for at the Unit Price in the Bid Form. Receipts or tickets shall be submitted to the Engineer to demonstrate disposal at an approved location in order to receive payment.

2. Allowance Items

The Bid includes an allowance for payment by the Contractor to local and state Authorities to obtain permits required to do this work. The allowance amount is to be added to the Total Bid for Project. Any unused portion of the allowance remaining at the completion of the contract shall revert to the Owner as a credit. The allowance is for permits ONLY and shall not include any mark-up.

- END OF SECTION -

SECTION 01040

COORDINATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall allow the Owner or his agents, and other project Contractors or their agents, to enter upon the work for the purpose of constructing, operating, maintaining, removing, repairing, altering, or replacing such pipes, sewers, conduits, manholes, wires, poles, or other structures and appliances which may be required to be installed at or in the work. The Contractor shall cooperate with all aforesaid parties and shall allow reasonable provisions for the prosecution of any other work by the Owner, or others, to be done in connection with his work, or in connection with normal use of the facilities.

B. Each Contractor shall cooperate fully with the Owner, the Engineer, and all other Contractors employed on the work, to effect proper coordination and progress to complete the project on schedule and in proper sequence. Insofar as possible, decisions of all kinds required from the Engineer shall be anticipated by the Contractor to provide ample time for inspection, or the preparation of instructions.

C. Each Contractor shall assume full responsibility for the correlation of all parts of his work with that of other Contractors. Each Contractor's superintendent shall correlate all work with other Contractors in the laying out of work. Each Contractor shall lay out his own work in accordance with the Drawings, Specifications, and instructions of latest issue and with due regard to the work of other Contractors.

D. Periodic coordinating conferences shall be held per Section 01200, Project Meetings, of these Contract Documents.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 01070

ABBREVIATIONS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The following is a partial list of typical abbreviations which may be used in the Specifications, and the organizations to which they refer:

AASHTO	-	American Association of State Highway and Transportation Officials
ACI	-	American Concrete Institute
ACIFS	-	American Cast Iron Flange Standards
AFBMA	-	Anti-Friction Bearing Manufacturer's Association
AGA	-	American Gas Association
AGMA	-	American Gear Manufacturers Association
AIA	-	American Institute of Architects
AISC	-	American Institute of Steel Construction
AISI	-	American Iron and Steel Institute
ANSI	-	American National Standard Institute
API	-	American Petroleum Institute
ASCE	-	American Society of Civil Engineers
ASHRAE	-	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
AWS	-	American Welding Society
AWWA-	American Water Works Association	
CEMA	-	Conveyor Equipment Manufacturer's Association
CRSI	-	Concrete Reinforcing Steel Institute
DIPRA	-	Ductile Iron Pipe Research Association
Fed Spec	-	Federal Specifications
IEEE	-	Institute of Electrical and Electronic Engineers
IPCEA	-	Insulated Power Cable Engineers Association
ISO	-	Insurance Services Offices
NBS	-	National Bureau of Standards
NCDOT	-	North Carolina Department of Transportation
NEC	-	National Electric Code
NEMA	-	National Electrical Manufacturers Association
OSHA	-	Occupational Safety and Health Act
PCI	-	Precast Concrete Institute
UL	-	Underwriters Laboratories, Inc.
USGS	-	United States Geological Survey

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PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01090

REFERENCE STANDARDS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Wherever reference is made to any published standards, codes, or standard specifications, it shall mean the latest standard code, specification, or tentative specification of the technical society, organization, or body referred to, which is in effect at the date of invitation for Bids.

B. All materials, products, and procedures used or incorporated in the work shall be in strict conformance with applicable codes, regulations, specifications, and standards.

C. A partial listing of codes, regulations, specifications, and standards includes the following:

Air Conditioning and Refrigeration Institute (ARI)

Air Diffusion Council (ADC)

Air Moving and Conditioning Association (AMCA)

The Aluminum Association (AA)

American Architectural Manufacturers Association (AAMA)

American Concrete Institute (ACI)

American Gear Manufacturers Association (AGMA)

American Hot Dip Galvanizers Association (AHDGA)

American Institute of Steel Construction, Inc. (AISC)

American Iron and Steel Institute (AISI)

American National Standards Institute (ANSI)

American Society of Civil Engineers (ASCE)

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)

American Society of Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

American Standards Association (ASA)

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American Water Works Association (AWWA)

American Welding Society (AWS)

American Wood-Preserver's Association (AWPA)

Anti-Friction Bearing Manufacturers Association (AFBMA)

Building Officials and Code Administrators (BOCA)

Conveyor Equipment Manufacturers Association (CEMA)

Consumer Product Safety Commission (CPSC)

Factory Mutual (FM)

Federal Specifications

Instrument Society of America (ISA)

Institute of Electrical and Electronics Engineers (IEEE)

National and Local Fire Codes

Lightning Protection Institute (LPI)

National Electrical Code (NEC)

National Electrical Manufacturer's Association (NEMA)

National Electrical Safety Code (NESC)

National Electrical Testing Association (NETA)

National Fire Protection Association (NFiPA)

Regulations and Standards of the Occupational Safety and Health Act (OSHA)

Southern Building Code Congress International, Inc. (SBCCI)

Sheet Metal & Air Conditioning Contractors National Association (SMACCNA)

Standard Building Code

Standard Mechanical Code

Standard Plumbing Code

Uniform Building Code (UBC)

Underwriters Laboratories Inc. (UL)

D. Contractor shall, when required, furnish evidence satisfactory to the Engineer that materials and methods are in accordance with such standards where so specified.

E. In the event any questions arise as to the application of these standards or codes, copies shall be supplied on-site by the Contractor.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

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SECTION 01200

PROJECT MEETINGS

PART 1 -- GENERAL

1.01 PRE-BID MEETING

A. A pre-bid meeting will be held at the time and place to be designated in the Instructions to Bidders.

B. The Engineer will be available to discuss the project and answer pertinent questions. No oral interpretation will be made as to the meaning of the Documents. Interpretation, if deemed necessary by the Engineer, will be in the form of an Addendum to the Contract Documents.

1.02 PRECONSTRUCTION MEETING

A. A preconstruction meeting will be held after Award of Contract, but prior to starting work at the site.

B. Attendance:

1. Owner

2. Engineer

3. Contractor

4. Major subcontractors

5. Safety representative

6. Representatives of governmental or other regulatory agencies.

C. Minimum Agenda:

1. Tentative construction schedule

2. Critical work sequencing

3. Designation of responsible personnel

4. Processing of Field Decisions and Change Orders

5. Adequacy of distribution of Contract Documents

6. Submittal of Shop Drawings and samples

7. Procedures for maintaining record documents

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8. Use of site and Owner's requirements

9. Major equipment deliveries and priorities

10. Safety and first aid procedures

11. Security procedures

12. Housekeeping procedures

13. Processing of Partial Payment Requests

14. General regard for community relations

1.03 PROGRESS MEETING

A. Progress meetings will be held monthly at the Plant Site during the performance of the work of this Contract. Additional meetings may be called as progress of work dictates.

B. Engineer will preside at meetings and record minutes of proceedings and decisions. Engineer will distribute copies of minutes to participants.

C. Attendance:

1. Engineer

2. Contractor

3. Subcontractors, only with Engineer's approval or request, as pertinent to the agenda

D. Minimum Agenda:

1. Review and approve minutes of previous meetings.

2. Review progress of Work since last meeting.

3. Review proposed 30-60 day construction schedule.

4. Note and identify problems which impede planned progress.

5. Develop corrective measures and procedures to regain planned schedule.

6. Revise construction schedule as indicated and plan progress during next work period.

7. Maintaining of quality and work standards.

8. Complete other current business.

9. Schedule next progress meeting.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

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SECTION 01300

SUBMITTALS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Progress Schedule

1. Within thirty (30) days after issuance of the Notice to Proceed, the Contractor shall prepare and submit his proposed progress schedule electronically in PDF format to the Engineer for review and approval.

2. If so required, the schedule shall be revised until it is approved by the Engineer.

3. Schedule shall be updated monthly, depicting progress to the last day of the month and five (5) copies submitted to the Engineer not later than the fifth day of the month, and prior to the application for progress payment. Failure to provide monthly schedule updates will be grounds for the Engineer or Owner to withhold progress payment approval.

4. Schedule shall be prepared in the form of a horizontal bar chart showing in detail the proposed sequence of the work and identifying construction activities for each structure and for each portion of work.

5. Schedule shall be time scaled, identifying the first day of each week. The Schedule shall be provided with estimated dates for Early Start, Early Finish, Late Start and Late Finish. The work shall be scheduled to complete the Project within the Contract time. The Late Finish date shall equal the Contract Completion Date.

6. Schedule shall show duration (number of days) and float for each activity. Float shall be defined as the measure of leeway in starting or completing a scheduled activity without adversely affecting the project completion date established by the Contract Documents.

7. Updated schedule shall show all changes since the previous submittal.

8. All revisions to the schedule must have the prior approval of the Engineer.

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B. Equipment and Material Orders Schedule

1. Contractor shall prepare and submit electronically his schedule of principal items of equipment and materials to be purchased to the Engineer for review and approval.

2. If so required, the schedule shall be revised until it is approved by the Engineer.

3. Schedule shall be updated monthly and submitted electronically in PDF format to the Engineer not later than the fifth day of every month with the application for progress payment.

4. The updated schedule shall be based on the Progress Schedule developed under the requirements of Paragraph 1.01(A) of this Section.

5. Schedule shall be in tabular form with appropriate spaces to insert the following information for principal items of equipment and materials:

    a. Dates on which Shop Drawings are requested and received from the manufacturer.

    b. Dates on which certification is received from the manufacturer and transmitted to the Engineer.

    c. Dates on which Shop Drawings are submitted to the Engineer and returned by the Engineer for revision.

    d. Dates on which Shop Drawings are revised by manufacturer and resubmitted to the Engineer.

    e. Date on which Shop Drawings are returned by Engineer annotated either "Furnish as Submitted" or "Furnish as Corrected".

    f. Date on which accepted Shop Drawings are transmitted to manufacturer.

    g. Date of manufacturer's scheduled delivery.

    h. Date on which delivery is actually made.

C. Working Drawings

1. Within thirty (30) days after the Notice to Proceed, each prime Contractor shall prepare and submit an electronic (PDF) copy of his preliminary schedule of Working Drawing submittals to the Engineer for review and approval. If so required, the schedule shall be revised until it is approved by the Engineer.

2. Working Drawings include, but are not limited to, Shop Drawings, layout drawings in plan and elevation, installation drawings, elementary wiring diagrams, interconnecting wiring diagrams, manufacturer's data, etc. Contractor shall be responsible for securing all of the information, details, dimensions, Drawings, etc., necessary to prepare the Working Drawings required and necessary under this Contract and to fulfill all other requirements of his Contract. Contractor shall secure such information, details, Drawings, etc., from all possible sources including the Drawings, Working Drawings prepared by subcontractors, Engineers, suppliers, etc.

3. Working Drawings shall accurately and clearly present the following:

   a. All working and installation dimensions.

   b. Arrangement and sectional views.

   c. Units of equipment in the proposed positions for installation, details of required attachments and connections, and dimensioned locations between units and in relation to the structures.

   d. Necessary details and information for making connections between the various trades including, but not limited to, power supplies and interconnecting wiring between units, accessories, appurtenances, etc.

4. In the event that the Engineer is required to provide additional engineering services as a result of a substitution of materials or equipment by the Contractor, the additional services will be provided in accordance with Section 01010 - Summary of Work, and will be covered in supplementary or revised Drawings which will be issued to the Contractor. All changes indicated that are necessary to accommodate the equipment and appurtenances shall be incorporated into the Working Drawings submitted to the Engineer.

5. Working Drawings specifically prepared for this Project shall be on mylar or other approved reproducible material sheets of the same size as the Drawings. Working Drawings shall conform to recognized drafting standards and be neat, legible and drawn to a large enough scale to show in detail the required information.

6. The Drawings are used for engineering and general arrangement purposes only and are not to be used for Working Drawings.

7. Shop Drawings

   a. Contractor shall submit for review by the Engineer Shop Drawings for all fabricated work and for all manufactured items required to be furnished by the Contract Documents.

   b. Structural and all other layout Drawings prepared specifically for the Project shall have a plan scale of not less than 1/4-inch = 1 foot.

   c. Where manufacturer's publications in the form of catalogs, brochures, illustrations or other data sheets are submitted in lieu of prepared Shop Drawings, such submittals shall specifically indicate the item for which approval is requested. Identification of items shall be made in ink, and submittals showing only general information are not acceptable.

8. Layout and Installation Drawings

   a. Contractor shall prepare and submit for review by the Engineer layout and installation drawings for all pipes, valves, fittings, sewers, drains, heating and ventilation ducts, all electrical, heating, ventilating and other conduits, plumbing lines, electrical cable trays, lighting fixture layouts, and circuiting, instrumentation, interconnection wiring diagrams, communications, power supply, alarm circuits, etc., under this Contract. The final dimensions, elevation, location, etc., of pipe, valves, fittings, sewers, ducts, conduits, electrical cable trays, equipment, etc., may depend upon the dimensions of equipment and valves to be furnished by the Contractor.

   b. Layout and installation drawings are required for both interior and exterior piping, valves, fittings, sewers, drains, heating and ventilation ducts, conduits, plumbing lines, electrical cable trays, etc.

   c. Layout and installation Drawings shall show connections to structures, equipment, sleeves, valves, fittings, etc.

   d. Drawings shall show the location and type of all supports, hangers, foundations, etc., and the required clearances to operate valves, equipment, etc.

   e. The Drawings for pipes, ducts, conduits, etc., shall show all 3-inch and larger electrical conduits and pressure piping, electrical cable trays, heating and ventilation ducts or pipes, structure, manholes or any other feature within four (4) feet (measured as the clear dimension) from the pipe duct, conduit, etc., for which the profile is drawn.

9. Contractor Responsibilities

a. All submittals from subcontractors, manufacturers or suppliers shall be sent directly to the Contractor for checking. Contractor shall thoroughly check all Drawings for accuracy and conformance to the intent of the Contract Documents. Drawings found to be inaccurate or otherwise in error shall be returned to the subcontractors, manufacturers, or suppliers by the Contractor for correction before submitting them to the Engineer.

b. All submittals shall be bound, dated, properly labeled and consecutively numbered. Information on the label shall indicate Specification Section, Drawing number, subcontractor's, manufacturer's or supplier's name and the name or type of item the submittal covers. Each part of a submittal shall be marked and tabulated.

c. Working Drawings shall be submitted as a single complete package including all associated drawings relating to a complete assembly of the various parts necessary for a complete unit or system.

d. Shop Drawings shall be submitted as a single complete package for any operating system and shall include all items of equipment and any mechanical units involved or necessary for the functioning of such system. Where applicable, the submittal shall include elementary wiring diagrams showing circuit functioning and necessary interconnection wiring diagrams for construction.

e. ALL SUBMITTALS SHALL BE THOROUGHLY CHECKED BY THE CONTRACTOR FOR ACCURACY AND CONFORMANCE TO THE INTENT OF THE CONTRACT DOCUMENTS BEFORE BEING SUBMITTED TO THE ENGINEER AND SHALL BEAR THE CONTRACTOR'S STAMP OF APPROVAL CERTIFYING THAT THEY HAVE BEEN SO CHECKED. SUBMITTALS WITHOUT THE CONTRACTOR'S STAMP OF APPROVAL WILL NOT BE REVIEWED BY THE ENGINEER AND WILL BE RETURNED TO THE CONTRACTOR.

f. If the submittals contain any departures from the Contract Documents, specific mention thereof shall be made in the Contractor's letter of transmittal. Otherwise, the review of such submittals shall not constitute approval of the departure.

g. No materials or equipment shall be ordered, fabricated, shipped or any work performed until the Engineer returns to the Contractor the submittals, herein required, annotated "Furnish as Submitted", "Furnish as Corrected", or “Furnish as Corrected – Confirm.” If a submittal is returned “Furnish as Corrected – Confirm” the portions of work covered by the submittal that require confirmation by the Engineer shall not be ordered, fabricated, shipped, or any work performed until those portions are approved in a subsequent submittal either "Furnish as Submitted" or "Furnish as Corrected".

h. Where errors, deviations, and/or omissions are discovered at a later date in any of the submittals, the Engineer's prior review of the submittals does not relieve the Contractor of the responsibility for correcting all errors, deviations, and/or omissions.

10. Procedure for Review

a. Submittals shall be transmitted in sufficient time to allow the Engineer at least thirty (30) working days for review and processing.

b. Contractor shall transmit copies of all technical data or drawings to be reviewed. electronically, in a PDF format. Two (2) hard-copy shall be submitted of submittals too large to be sent electronically. An electronic copy on CD or DVD shall also be included with this hard-copy.

c. Submittal shall be accompanied by a letter of transmittal containing date, project title, Contractor's name, number and titles of submittals, a list of relevant specification sections, notification of departures from any Contract requirement, and any other pertinent data to facilitate review.

d. Submittals will be annotated by the Engineer in one of the following ways:

"Furnish as Submitted" (FAS) - no exceptions are taken

"Furnish as Corrected" (FAC) - minor corrections are noted and shall be made.

“Furnish as Corrected – Confirm” (FACC) - some corrections are noted and a partial resubmittal or additional information are required as specifically requested.

"Revise and Resubmit" (R&R) - major corrections are noted and a full resubmittal is required.

"Rejected” – submittal is not in conformance with Contract Documents and deviations are too numerous to list. A completely revised submittal is required.

"Receipt Acknowledged” (RACK) – submittal was received and was distributed for record purposes without review.

e. If a submittal is satisfactory to the Engineer in full or in part, the Engineer will annotate the submittal "Furnish as Submitted", "Furnish as Corrected", or “Furnish as Corrected – Confirm” and transmit electronically to the Contractor. If hardcopies were originally submitted, the Engineer will retain one (1) copy and return remaining copies to the Contractor. In the case of “Furnish as Corrected – Confirm” a partial resubmittal or additional information are required as specifically requested.

f. If a full resubmittal is required, the Engineer will annotate the submittal "Revise and Resubmit" and transmit electronically to the Contractor for appropriate action. If hardcopies were originally submitted, the Engineer will retain one (1) copy and return remaining copies to the Contractor.

g. Contractor shall continue to resubmit submittals in part if they are returned “Furnish as Corrected – Confirm” or in full if they are returned “Revise and Resubmit” as required by the Engineer until submittals are acceptable to the Engineer. It is understood by the Contractor that Owner may charge the Contractor the Engineer's charges for review in the event a submittal is not approved (either "Furnish as Submitted" or "Furnish as Corrected") by the third submittal for a system or piece of equipment. These charges shall be for all costs associated with engineering review, meetings with the Contractor or manufacturer, etc., commencing with the fourth submittal of a system or type of equipment submitted for a particular Specification Section.

h. Acceptance of a Working Drawing by the Engineer will constitute acceptance of the subject matter for which the Drawing was submitted and not for any other structure, material, equipment or appurtenances indicated or shown.

11. Engineer's Review

a. Engineer's review of the Contractor's submittals shall in no way relieve the Contractor of any of his responsibilities under the Contract. An acceptance of a submittal shall be interpreted to mean that the Engineer has no specific objections to the submitted material, subject to conformance with the Contract Drawings and Specifications.

b. Engineer's review will be confined to general arrangement and compliance with the Contract Drawings and Specifications only, and will not be for the purpose of checking dimensions, weights, clearances, fittings, tolerances, interferences, coordination of trades, etc.

12. Record Working Drawings

a. Contractor shall maintain current record drawings onsite for the Engineer’s review. Record drawings shall be updated monthly at a minimum.

b. Prior to final payment, the Contractor shall furnish the Engineer one complete set of all accepted Working Drawings, including Shop Drawings, for equipment, piping, electrical work, heating system, ventilating system, air conditioning system, instrumentation system, plumbing system, structural, interconnection wiring diagrams, etc.

c. Working Drawings furnished shall be corrected to include any departures from previously accepted Drawings.

D. Operation and Maintenance Manuals

1. Two (2) preliminary hardcopy versions and an electronic copy, in PDF format, of Operation and Maintenance Manuals, prepared specifically for this Project, shall be furnished for each item of equipment furnished under this Contract. The preliminary manuals shall be provided to the Engineer not less than 60 days prior to the start-up of the respective equipment.

2. The preliminary manuals shall be reviewed by the Engineer prior to the Contractor submitting final copies for distribution to the Owner. Following review of the preliminary copies of the Operation and Maintenance Manuals, one (1) copy will be returned to the Contractor with required revisions noted, or the acceptance of the Engineer noted.

3. Manuals shall contain complete information in connection with assembly, operation, lubrication, adjustment, wiring diagrams and schematics, maintenance, and repair, including detailed parts lists with drawings or photographs identifying the parts.

4. Manuals furnished shall be assembled and bound in separate volumes, by major equipment items or trades, and properly indexed to facilitate locating any required information. In addition, manuals should be labeled on the front cover with the project, name, equipment description, and manufacturer contact information.

5. Engineer and the Owner shall be the sole judge of the acceptability and completeness of the manuals and may reject any submittal for insufficient information included, incorrect references and/or the manner in which the material is assembled.

6. Following the Engineer's review of the preliminary manuals, the Contractor shall submit three (3) paper copies and two (2) electronic copies of the final Operation and Maintenance Manuals to the Engineer. The manuals shall reflect the required revisions noted during the Engineer's review of the preliminary documents. Failure of the final manuals to reflect the required revisions noted by the Engineer during a review of the Preliminary documents will result in the manuals being returned to the Contractor. Acceptable final Operation and Maintenance Manuals shall be provided not less than two week prior to equipment start-up.

a. Hard copies shall be bound bearing suitable identification.

   i. Hard copies of each manual shall be prepared and delivered in substantial, permanent, three ring or three-post binders with a table of contents and suitable index tabs. Each binder shall be large enough to not inhibit turning of pages.
   ii. Binders shall not be greater than 3-inches thick. Manuals larger than 3-inches shall be separated into an appropriate number of volumes. Each volume containing data for three or more items of equipment shall include a table of contents and index tabs.
   iii. All manuals and other data shall be printed on heavy, first quality 8-1/2 x 11 inch paper, with standard three-hole punching.
   iv. Drawings and diagrams shall be reduced to 8-1/2 x 11 inches or 11 x 17 inches. Where reduction is not practical, larger drawings shall be folded separately and placed in envelopes, which are bound into the manuals. Each envelope shall be suitably identified on the outside.

b. Electronic manuals shall be in Adobe Acrobat's Portable Document Format (PDF), and shall be prepared at a resolution between 300 and 600 dots per inch (dpi), depending on document type. Optical Character Recognition (OCR) capture shall be performed on these documents. OCR settings shall be performed with the "original image with hidden text" option in Adobe Acrobat Exchange.

c. Documents prepared in PDF format shall be delivered without security settlings to permit editing, insertion, and deletion of material to update the manual provided by the manufacturer.

E. Certified Shop Test Reports

1. Each piece of equipment for which pressure, head, capacity, rating, efficiency, performance, function or special requirements are specified or implied shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and applicable test codes and standards. Contractor shall keep the Engineer advised of the scheduling of shop tests so that the Engineer may arrange for the witnessing or inspection at the proper time and place.

2. The Contractor shall secure from the manufacturers electronic PDF versions of the actual test data, the interpreted results and a complete description of the testing facilities and testing setup, all accompanied by a certificate of authenticity sworn to by a responsible official of the manufacturing company and notarized. These reports shall be forwarded to the Engineer for review.

3. In the event any equipment fails to meet the test requirements, the manufacturer shall make all necessary changes, adjustments or replacements and the tests shall be repeated, at no additional cost to the Owner or Engineer, until the equipment test requirements are acceptable to the Engineer.

4. No equipment shall be shipped to the Project until the Engineer notifies the Contractor, in writing, that the shop test reports are acceptable.

F. Samples

1. Contractor shall furnish for review all samples as required by the Contract Documents or requested by the Engineer.

2. Samples shall be of sufficient size or quantity to clearly illustrate the quality, type, range of color, finish or texture and shall be properly labeled to show the nature of the material, trade name of manufacturer and location of the work where the material represented by the sample will be used.

3. Samples shall be checked by the Contractor for conformance to the Contract Documents before being submitted to the Engineer and shall bear the Contractor's stamp of approval certifying that they have been so checked. Transportation charges on samples submitted to the Engineer shall be prepaid by the Contractor.

4. Engineer's review will be for compliance with the Contract Documents and his comments will be transmitted to the Contractor with reasonable promptness.

5. Accepted samples will establish the standards by which the completed work will be judged.

G. Construction Photographs

1. The General Contractor shall engage a competent photographer to take photographs at the locations and at such stages of the construction as directed by the Engineer.

2. Provide the equivalent of 36 different exposures per month for the duration of the Contract time. When directed by the Engineer, frequency of photographs may be increased to weekly sessions provided that the equivalent number of photographs is not exceeded. Engineer may waive requirements for photographs during inactive construction periods in favor of increased photographs during active construction sequences.

H. Pre-Construction Photos and Video

1. The General Contractor shall engage a competent photographer to take photographs at all locations associated with the project, and under the direction of the Engineer. Photographs shall include the existing structures that are to be modified and all concrete, asphalt pavements, curb and gutter, and fencing to remain in the project area.

2. The Contractor shall video the entire project site including all concrete and asphalt pavements, curb and gutter, fencing to remain, structures to be demolished, and existing structures that are to be modified. The original video image shall be turned over to the Engineer prior to beginning construction activities. The video shall be provided as an Audio Video Interleave (.avi) file and shall be provided on DVD+R/DVD-ROM compatible media only. The video shall clearly identify existing site and structural conditions prior to construction.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

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SECTION 01350

SEISMIC ANCHORAGE AND BRACING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all equipment, labor, materials, and services required to design and provide seismic restraint and bracing for all nonstructural architectural, mechanical, electrical, and plumbing components and their supports and attachments permanently attached to the primary structure in which the components are to be installed in accordance with the Contract Documents and the seismic restraint requirements of Chapter 13 in ASCE 7.

B. Furnish mechanical, electrical, and plumbing equipment manufacturer certifications showing seismic compliance in accordance with Chapter 13 of ASCE 7 for equipment designated as an essential component or to remain operational following a seismic event.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01450 – Special Inspections

B. Section 05010 – Metal Materials

C. Section 05050 – Metal Fastening

D. Section 06610 – Glass Fiber and Resin Fabrications

E. Section 15000 – Basic Mechanical Requirements

F. Section 15020 – Pipe Supports

G. Section 15400 – Plumbing

H. Section 15500 – HVAC Requirements

I. Section 16000 – Basic Electrical Requirements

J. Division 17 – Control and Information Systems

K. Further requirements for seismic anchorage and bracing may be included in other Sections of the Specifications. See section for the specific item in question.

1.03 DEFINITIONS

A. Nonstructural components: All architectural, mechanical, electrical or plumbing elements or systems and their supports or attachments provided under this contract which are permanently attached to the floors, roof, walls, columns and beams of newly constructed buildings, building additions, existing buildings or non-building structures.

1. Architectural nonstructural components include, but are not limited to, interior nonstructural walls and partitions, exterior wall panels and glazing elements, glass curtain walls, skylights, cabinets, suspended ceilings, fascias, and cladding.

2. Mechanical nonstructural components include, but are not limited to, HVAC units, fans, water and wastewater treatment process equipment, instrumentation cabinets, piping and ductwork.

3. Electrical nonstructural components include, but are not limited to, conduit systems, cable tray systems, boxes, transformers, panelboards, switchboards, switchgear, busway, individual motor controllers, motor control centers, variable frequency drives, automatic transfer switches, and lighting systems.

4. Plumbing nonstructural components include, but are not limited to, sprinkler systems and associated piping, and sump pumps.

B. Seismic Restraint: Attachments and supports, including braces, frames, legs, hangers, saddles, and struts which anchor and brace nonstructural components to minimize their displacement during an earthquake and transmit loads between non-structural components and their attachments to the structure or building.

C. Attachment: Elements including anchor bolts, welded connections, and mechanical fasteners which secure non-structural components or supports to the structure.

D. Hazardous: Toxic, flammable, explosive or corrosive materials in excess of building code mandated threshold quantities for non-hazardous condition.

E. Essential Components: Nonstructural components considered necessary to public safety for which the importance factor I_p applies, including:

1. Life safety systems which must function following an earthquake, including but not limited to, sprinklers for fire protection, emergency lighting, egress corridors and stairways, and smoke purge systems.

2. Components which contain, convey or support hazardous materials.

3. Components which are within or attached to an Occupancy or Risk Category IV structure as defined in ASCE 7 Chapter 1.

4. Process systems and elements designated below:

F. Nonbuilding Structures: All self-supporting structures which are supported by an independent foundation or by other structures which include, but are not limited to, storage tanks, silos, exhaust stacks, storage racks, and towers.

G. Delegated Design: Design of a structure or structural element(s) which has been deferred by the contract documents to be performed during the project construction stage, by a registered design professional retained by the contractor and with the design submitted as a shop drawing to the Engineer for record purposes.

1.04 EXEMPTIONS

A. The following nonstructural components are exempt from requiring seismic anchorage and bracing: (See paragraph 1.07.C herein for Seismic Design Category)

1. All architectural, mechanical, electrical and plumbing nonstructural components in Seismic Design Category A.

2. All mechanical, electrical and plumbing nonstructural components in Seismic Design Category B.

3. All architectural nonstructural components in Seismic Design Category B provided $I_p = 1.0$, except parapets supported by bearing or shear walls.

4. All mechanical, electrical and plumbing nonstructural components in Seismic Design Category C provided $I_p = 1.0$.

5. All mechanical, electrical and plumbing nonstructural components in Seismic Design Category D, E or F provided all the following apply:

a. $I_p = 1.0$.

b. Components are positively attached to the structure without consideration of frictional resistance and have flexible connections between the components and associated ductwork, piping and conduit.

c. Either of the following:

i. Component center of mass is 4 ft or less above a floor level and weighs 400 lbs or less.

ii. Component weighs 20 lbs or less or 5 plf or less for distribution systems.

6. Other exemptions as allowed by the Specifications, Codes and Standards referenced herein.

1.05 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. The building code shall be the version in effect at the time of Bid within the jurisdiction where the Work is located. All other referenced specifications, codes, and standards refer to the version as referenced by the building code. If no version is referenced by the building code, then the most current issue available at the time of Bid shall be used.

1. South Carolina Building Code

2. ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures

3. NFPA 13 Standard for Installation of Sprinkler Systems

4. FEMA 412 Installing Seismic Restraints for Mechanical Equipment

5. FEMA 413 Installing Seismic Restraints for Electrical Equipment

6. FEMA 414 Installing Seismic Restraints for Duct and Pipe

7. SMACNA Sheet Metal and Air Conditioning Contractors' National Association, Seismic Restraint Manual: Guidelines for Mechanical Systems

8. ACI 318 Building Code Requirements for Structural Concrete and Commentary

9. ACI 355.2 Qualifications of Post-Installed Mechanical Anchors in Concrete

10. ACI 355.4 Qualifications of Post-Installed Adhesive Anchors in Concrete

1.06 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Seismic anchorage and bracing shop drawings for all architectural, mechanical, electrical, and plumbing nonstructural components, elements and systems not meeting any of the exemptions in paragraph 1.4 above and do not have a design for seismic anchorage and bracing provided within the contract documents. Submittals shall include the following:

a. Component manufacturer's cut sheets and fabrication details for equipment bases and foundations, including dimensions, structural member sizes, support point locations and equipment operational loads. Equipment anchorage details shall clearly indicate anchor size, pattern, embedment and edge distance requirements to satisfy operational and seismic forces. Details shall also indicate grout, bearing pads, isolators, etc required for complete installation.

b. Design calculations, signed and sealed by a Professional Engineer currently registered in the State of South Carolina confirming the proposed seismic restraints and attachment will provide sufficient strength and stiffness to resist the design earthquake and limit damage to nonstructural components and the entire support is sufficient to resist the combined gravity and seismic loads. Separate calculation submittals for vertical and lateral load support systems shall not be allowed.

c. Detailed Shop Drawings, signed and sealed by a Professional Engineer currently registered in the State of South Carolina, showing specific details of the support design including material, installation, attachments, connection hardware, etc, and the restraint layout and location of all hangers and supports (resisting both gravity and seismic loads), including restraint orientation and direction of force(s) to be resisted. Within each submittal, the Contractor shall include a **cumulative** set of hanger and support location drawings (one cumulative 'living drawing for each building structure) containing all proposed mechanical, electrical and plumbing support locations submitted to date showing the locations of all support attachments to the primary structure. Load magnitudes shall be indicated at attachments to the structure where the sum of the reaction loads on a single member exceeds 1000 pounds vertically or exceeds 500 pounds horizontally. Unless requested by the Engineer, load magnitudes need not be submitted for load values less than these stated values. Separate shop drawing submittals for vertical and lateral load support systems shall not be allowed.

d. For components required to be certified as seismically qualified in accordance with paragraph 1.06.A.2 below, submit installation guidelines provided by the equipment manufacturer for proper seismic mounting of the equipment.

2. For each mechanical, electrical and plumbing nonstructural components and systems furnished, including associated equipment appurtenances and attachments, designated as essential components in Seismic Design Categories C through F, provide Manufacturer's Certification signed and sealed by a currently registered Professional Engineer in the State of South Carolina to show the component is seismically qualified in accordance with the Specifications, Codes, and Standards requirements referenced herein. The following requirements shall be met:

a. Seismic qualification shall be substantiated either by approved shake table testing or experience data, with the evidence of such qualification testing or experience data submitted to the Engineer along with the manufacturer's statement certifying the equipment shall remain operable following the design seismic event.

b. Components with hazardous contents shall also be certified by the manufacturer to maintain containment following the design seismic event based on analysis, approved shake table testing, or experience data. Evidence demonstrating compliance shall be submitted to the Engineer.

c. Seismic qualification testing shall be based on ASCE 7 and on a nationally recognized testing standard procedure such as ICC-ES AC 156.

3. For each mechanical, electrical and plumbing nonstructural components and systems furnished, including associated equipment appurtenances and attachments, designated as essential components in Seismic Design Categories C through F, provide Manufacturer's Certification signed and sealed by a currently registered Professional Engineer in the State of South Carolina to show the component is seismically qualified in accordance with the Specifications, Codes, and Standards requirements referenced herein. The following requirements shall be met:

a. Seismic qualification shall be substantiated either by approved shake table testing or experience data, with the evidence of such qualification testing or experience data submitted to the Engineer along with the manufacturer's statement certifying the equipment shall remain operable following the design seismic event.

b. Components with hazardous contents shall also be certified by the manufacturer to maintain containment following the design seismic event based on analysis, approved shake table testing, or experience data. Evidence demonstrating compliance shall be submitted to the Engineer.

c. Seismic qualification testing shall be based on ASCE 7 and on a nationally recognized testing standard procedure such as ICC-ES AC 156.

1.07 DESIGN REQUIREMENTS

A. Seismic restraints systems for nonstructural components shall be subject to the most current local Building Code in conjunction with the seismic provisions of the South Carolina Building Code (IBC) Section 1613 and referenced ASCE 7 Chapter 13.

B. Seismic restraints systems for nonbuilding structures shall be subject to the most current local Building Code in conjunction with the seismic provisions of the South Carolina Building Code (IBC) Section 1613 and referenced ASCE 7 Chapter 15,

C. Nonstructural components shall be assigned to the same Seismic Design Category as the structure they occupy or to which they are attached. Design of seismic support system and anchorage shall follow the site-specific seismic criteria noted on the drawings. Criteria shall include site-specific spectral response coefficients, site class, seismic design category, and risk category.

D. Component Importance Factor I_p shall be 1.5 for all essential nonstructural components noted in item 1.03.E above. All other nonstructural components shall utilize I_p = 1.0 unless noted otherwise.

E. Components shall be restrained and braced for earthquake forces both in the vertical and each orthogonal direction. Seismic restraint systems shall limit deflections of components per ASCE 7 and the displacements shall not impede component functionally and containment.

F. Anchorage shall be designed in accordance with ASCE 7. Mechanical fasteners used to secure nonstructural architectural, mechanical, electrical and plumbing components shall meet the requirements of Specification Section 05050. All mechanical fasteners used to anchor essential components and other elements so designated in Specification Section 05050 shall be considered Structural Anchors.

G. Avoid crossing structural expansion joints with seismic supports or bracing. Nonstructural components shall not be attached to multiple structure elements which may respond differently in an earthquake without provisions to accommodate independent movement. Flexible expansion loops or offsets, flexible joints, bellows type pipe expansion joints, couplings, etc shall be provided at structure expansion joints to allow for independent structure movement and thermal movement of piping, ductwork and conduit. Minimum movement capability in the vertical and each orthogonal direction shall equal the width of the joint.

H. Provide flexible connections, piping, conduit, etc at foundation levels where below grade utilities enter into the structure.

I. Design of support system for components with multiple attachments shall take into account the stiffness and ductility of the supporting members. Equipment designed as free-standing shall only be attached at its base. Use of non-free-standing equipment requiring both vertical and lateral attachment is contingent upon loads applied to the structure and requires approval by the Engineer.

J. The seismic restraint design shall be based on actual equipment data (dimensions, weight, center of gravity, etc) obtained from the specifications or the approved equipment manufacturer. The equipment manufacturer shall verify the attachment points on the equipment can safely withstand the combination of seismic, self-weight and other loads imposed.

K. Attachments of nonstructural component supports and seismic restraints causing the building structure slabs, beams, walls, columns, etc. to be overstressed shall not be permitted.

L. Where the weight of a nonstructural component is greater than or equal to 25 percent of the effective seismic weight (as defined by ASCE 7) of the structure it is attached to, the component shall be classified as a nonbuilding structure and its support designed in accordance with ASCE 7 Chapter 15.

M. No reaction loads (either vertical or lateral) from nonstructural component supports and seismic restraints shall be allowed on any element where design has been delegated unless the additional loads on the element have been coordinated with the delegated designer and the submittal is accompanied by a sealed letter from the delegated designer indicating the element has been designed to support the reaction loads.

N. Reaction loads from nonstructural component supports and seismic restraints shall be transferred directly to the primary structural members, with no components supported from secondary members unless otherwise approved.

O. No holes shall be drilled into any structural steel for attachment of component supports without prior approval of the Engineer.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Seismic restraints and braces shall be constructed of appropriate materials and connecting hardware to provide a continuous load path between the component and supporting structure of sufficient strength and stiffness to resist the calculated design seismic forces and displacements.

B. Component restraint, bracing and connection materials shall be compatible with and in general match the component and component gravity support materials. Contact between dissimilar metals shall be prevented. See Section 15020 – Pipe Supports for additional details.

C. Post-installed concrete anchors used for seismic restraint and bracing anchorage shall be considered structural anchors per Section 05050 and shall be prequalified for use in seismic applications.

D. Powder actuated fasteners in steel or concrete shall not be used for sustained tension loads in Seismic Design Categories D, E or F unless approved for seismic loading or specifically exempted by ASCE 7. Powder actuated fasteners in masonry shall not be used unless approved for seismic loading regardless of Seismic Design Category.

E. Friction clips shall not be used in Seismic Design Categories D, E or F for supporting sustained tension loads in combination with resisting seismic forces. C-type and large flange clamps may be used for hanger attachments provided restraining straps meeting NFPA 13 requirements are utilized and loosening of threaded connections is prevented by lock nuts, burred threads, etc.

PART 3 -- EXECUTION

3.01 INSTALLATION OF SEISMIC RESTRAINTS AND ANCHORAGES

A. No components, seismic anchorages or restraints shall be installed prior to review and acceptance.

B. Seismic certified equipment shall be installed per the manufacturer's recommendations. Fasteners shall meet manufacturer's requirements.

- END OF SECTION -

SECTION 01400

QUALITY CONTROL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Testing Laboratory Services

1. Laboratory testing and checking required by the Specifications, including the cost of transporting all samples and test specimens, shall be provided and paid for by the Owner unless otherwise indicated in the Specifications.

2. Materials to be tested include, but are not necessarily limited to the following: cement, concrete aggregate, concrete, bituminous paving materials, structural and reinforcing steel, waterproofing, select backfill, crushed stone or gravel and sand.

3. Tests required by the Owner shall not relieve the Contractor from the responsibility of supplying test results and certificates from manufacturers or suppliers to demonstrate conformance with the Specifications.

4. Procedure

a. The Contractor shall plan and conduct his operations to permit taking of field samples and test specimens, as required, and to allow adequate time for laboratory tests.

b. The collection, field preparation and storage of field samples and test specimens shall be as directed by the Engineer with the cooperation of the Contractor.

5. Significance of Tests

a. Test results shall be binding on both the Contractor and the Owner, and shall be considered irrefutable evidence of compliance or noncompliance with the Specification requirements, unless supplementary testing shall prove, to the satisfaction of the Owner, that the initial samples were not representative of actual conditions.

6. Supplementary and Other Testing

a. Nothing shall restrict the Contractor from conducting tests he may require. Should the Contractor at any time request the Owner to consider such test results, the test reports shall be certified by an independent testing laboratory acceptable to the Owner. Testing of this nature shall be conducted at the Contractor's expense.

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1.02 FIELD TESTING OF EQUIPMENT

A. All equipment shall be set, aligned and assembled in conformance with the manufacturer's drawings and instructions.

B. Preliminary Field Tests

1. As soon as conditions permit, after the equipment has been secured in its permanent position, the Contractor shall check the equipment for alignment, direction of rotation and that it is free from defects.

2. Contractor shall flush all bearings, gear housings, etc., in accordance with the manufacturer's recommendations, to remove any foreign matter accumulated during shipment, storage or erection. Lubricants shall be added as required by the manufacturer's instructions.

3. Preliminary field tests must be completed before equipment is subjected to final field tests.

C. Final Field Tests

1. Upon completion of the installation, and at a time approved by the Engineer, equipment will be tested by operating it as a unit with all related piping, ducting, electrical controls and mechanical operations.

2. The equipment will be placed in continuous operation as prescribed or required and witnessed by the Engineer or his assigned representative and the Owner or his assigned representative.

3. The tests shall prove that the equipment and appurtenances are properly installed, meet their operating cycles and are free from defects such as overheating, overloading, and undue vibration and noise. Equipment shall be tested for the characteristics as specified for the item.

4. Each pump shall be tested at maximum rated speed for at least four points on the pump curve for capacity, head and electric power input. The rated motor nameplate current and power shall not be exceeded at any point within the specified range. Vibrometer readings shall be taken when directed by the Engineer and the results recorded. Additional tests shall be performed as prescribed in other sections of the Specifications.

5. Pumps with drive motors rated at less than five horsepower shall only be tested for excess current or power when overheating or other malfunction becomes evident in general testing.

6. Until final field tests are acceptable to the Engineer, the Contractor shall make all necessary changes, readjustments and replacements at no additional cost to the Owner.

7. Defects which cannot be corrected by installation adjustments will be sufficient grounds for rejection of any equipment.

8. Upon acceptance of the field tests, no further construction work will be performed on the unit, except as required during start-up operations and directed by the Engineer.

9. All costs in connection with such tests including all materials, equipment, instruments, labor, etc., shall be borne by the Contractor.

1.03 IMPERFECT WORK, EQUIPMENT, OR MATERIALS

A. Any defective or imperfect work, equipment, or materials furnished by the Contractor which is discovered before the final acceptance of the work, as established by the Certificate of Substantial Completion, or during the subsequent guarantee period, shall be removed immediately even though it may have been overlooked by the Engineer and estimated for payment. Any equipment or materials condemned or rejected by the Engineer shall be immediately removed from the site. Satisfactory work or materials shall be substituted for that rejected.

B. The Engineer may order tests of imperfect or damaged work, equipment, or materials to determine the required functional capability for possible acceptance, if there is no other reason for rejection. The cost of such tests shall be borne by the Contractor; and the nature, tester, extent and supervision of the tests will be as determined by the Engineer. If the results of the tests indicate that the required functional capability of the work, equipment, or material was not impaired, consistent with the final general appearance of same, the work, equipment, or materials may be deemed acceptable. If the results of such tests reveal that the required functional capability of the questionable work, equipment, or materials has been impaired, then such work, equipment, or materials shall be deemed imperfect and shall be replaced. The Contractor may elect to replace the imperfect work, equipment, or material in lieu of performing the tests.

1.04 INSPECTION AND TESTS

A. The Contractor shall allow the Engineer ample time and opportunity for testing materials and equipment to be used in the work. He shall advise the Engineer promptly upon placing orders for material and equipment so that arrangements may be made, if desired, for inspection before shipment from the place of manufacture. The Contractor shall at all times furnish the Engineer and his representatives, facilities including labor, and allow proper time for inspecting and testing materials, equipment, and workmanship. The Contractor must anticipate possible delays that may be caused in the execution of his work due to the necessity of materials and equipment being inspected and accepted for use. The Contractor shall furnish, at his own expense, all samples of materials required by the Engineer for testing, and shall make his own arrangements for providing water, electric power, or fuel for the various inspections and tests of structures and equipment.

B. The Contractor shall furnish the services of representatives of the manufacturers of certain equipment, as prescribed in other Sections of the Specifications. The Contractor shall also place his orders for such equipment on the basis that, after the equipment has been tested prior to final acceptance of the work, the manufacturer will furnish the Owner with certified statements that the equipment has been installed properly and is ready to be placed in functional operation. Tests and analyses required of equipment shall be paid for by the Contractor, unless specified otherwise in the Section which covers a particular piece of equipment.

C. Where other tests or analyses are specifically required in other Sections of these Specifications, the cost thereof shall be borne by the party (Owner or Contractor) so designated in such Sections. The Owner will bear the cost of all tests, inspections, or investigations undertaken by the order of the Engineer for the purpose of determining conformance with the Contract Documents if such tests, inspection, or investigations are not specifically required by the Contract Documents, and if conformance is ascertained thereby. Whenever nonconformance is determined by the Engineer as a result of such tests, inspections, or investigations, the Contractor shall bear the full cost thereof or shall reimburse the Owner for said cost. In this connection, the cost of any additional tests and investigations, which are ordered by the Engineer to ascertain subsequent conformance with the Contract Documents, shall be borne by the Contractor.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01450

SPECIAL INSPECTIONS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. This section defines the requirements for Special Inspections as required by Section 1704 of the South Carolina Building Code (SCBC) and any State or local amendments.

B. The Engineer will prepare a Statement of Special Inspections, which identifies the type and extent of required Special Inspections. The Owner will retain one or more Special Inspections Agencies to perform Special Inspection services. These Agencies shall be independent from the Contractor and approved by the Building Official.

C. The Contractor shall plan and conduct his operations as to schedule and allow Special Inspections, providing adequate time and safe access for inspections. The Contractor shall coordinate requirements for Special Inspections with the Special Inspections Agency.

D. Special Inspections shall be in addition to inspections performed by Building Officials that are specified in SCBC Section 109.

E. Special Inspections shall be in addition to any Structural Observations required by SCBC Section 1710.

F. Special Inspections do not supersede other inspections and testing required by the Contract Documents to satisfy the Contractor's quality control responsibility. Contractor shall be responsible for all costs associated with quality control requirements as required by other sections of the Specifications.

G. Special Inspections shall not relieve Contractor's obligation to perform and complete work in accordance with Contract Documents. Results of Special Inspections activities, including any discrepancies that are noted or not noted, shall never constitute an acceptance of work that is not in accordance with the Contract Documents.

H. This section does not apply to construction equipment, shoring, earth retention systems, and temporary structures used by the Contractor in construction and not detailed in the Contract Documents. The Contractor shall be solely responsible for means, methods, techniques, sequences, or procedures of construction and any associated building code requirements.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Special Inspections requirements apply to work detailed in other sections of the Specifications. Special Inspections requirements shall be in addition to any other inspection or quality control requirements detailed in other sections of the Specifications. See individual specification sections for type of work in question.

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1.03 DEFINITIONS

A. Periodic Special Inspections: The part-time or intermittent observation of work requiring Special Inspection by a Special Inspector who is present in the area where the work has been or is being performed and at the completion of the work.

B. Continuous Special Inspections: The full-time observation of work requiring Special Inspection by a Special Inspector who is present in the area where the work is being performed.

C. Engineer: The Registered Design Professional in Responsible Charge of each building system. These systems include structural, mechanical, electrical, and architectural components.

D. Special Inspections Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, which has been approved by the Building Official and is retained by the Owner.

E. Special Inspector: Individual employed by or retained by the Special Inspections Agency who is qualified in inspection of a particular type of construction and conducts inspection activities in that type of construction, as required by this section.

F. Statement of Special Inspections: Document prepared by the Engineer and submitted to the Building Official which identifies the type and extent of required Special Inspections.

G. Approved Fabricator: Fabricator who has been registered and approved by the Building Official to perform a particular type of work without Special Inspections.

1.04 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents and all other documents referenced in the specifications. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1.	South Carolina Building Code	
2.	ACI 318	Building Code Requirements for Structural Concrete
3.	ACI 530.1/ASCE 6	Specifications for Masonry Structures
4.	AISC	"Code of Standard Practice."
5.	AISC	"Specification for Structural Steel Buildings".
6.	AISC 348	"The 2009 RCSC Specification for Structural Joints".
7.	AWS	"Structural Welding Code".
8.	Aluminum Association	Specifications for Aluminum Structures

1.05 SUBMITTALS

A. The Contractor shall submit the following in accordance with Section 01300, Submittals.

1. The Contractor shall submit a written statement of responsibility to the Building Official and Engineer using the attached form entitled “Contractor’s Statement of Responsibility” prior to beginning work. A statement is required from each Contractor who has responsibility for construction or fabrication of a main wind- or seismic-force-resisting system, designated seismic system, or a wind- or seismic-resisting-component listed in the Statement of Special Inspections.

2. The Contractor shall submit qualifications of any fabricators they intend to use that may qualify as Approved Fabricators to the Special Inspections Agency for review.

B. The Special Inspections Agency shall submit the following in accordance with Section 01300, Submittals.

1. The Special Inspections Agency shall provide a statement of qualifications showing relative experience, training, and certification(s) for each Special Inspector to the Building Official, if requested.

2. The Special Inspections Agency shall review fabricator qualifications and submit them to the Building Official for approval as an Approved Fabricator if requested.

3. Special Inspectors shall keep detailed inspection records, including all inspections, tests, similar services, and any discrepancies and corrections. Any discrepancies and corrections shall be reported to the Building Official and the Engineer in all required reports, unless otherwise required by the Building Official.

4. The Special Inspections Agency shall submit Interim Reports to the Building Official and the Engineer documenting required Special Inspections and correction of any discrepancies using the attached form entitled “Interim Report of Special Inspections” at the frequency specified in the Statement of Special Inspections.

5. The Special Inspections Agency shall submit to the Building Official and the Engineer a Final Report documenting required Special Inspections and correction of any discrepancies using the attached form entitled “Final Report of Special Inspections.” The Final Report shall be submitted at a point in time agreed upon by the Owner and the Building Official at the Pre-inspection Meeting.

6. Where work is done by Approved Fabricators, the Special Inspections Agency shall coordinate the submittal of a certificate of compliance to the Building Official and Engineer using the attached form entitled “Fabricator’s Certificate of Compliance.”

1.06 SPECIAL INSPECTOR QUALIFICATIONS

Special Inspectors shall meet minimum qualifications established by the Building Official and shall be approved by the Building Official.

1.07 OFF-SITE FABRICATIONS

A. When structural elements or assemblies are fabricated off site, Special Inspections are required to be performed in the fabricator's shop unless the fabricator is an Approved Fabricator. Special Inspections are not required if work is done on the premises of an Approved Fabricator.

B. Fabricators shall maintain detailed fabrication and quality control procedures to ensure workmanship and conformance with Contract Documents and reference standards. The Special Inspections Agency shall review the fabricator's quality control procedures and coordinate required Special Inspections with the fabricator and the Contractor.

C. The Contractor shall submit qualifications of fabricators seeking Approved Fabricator status to the Special Inspections Agency for review. Approval as an Approved Fabricator shall be given by the Building Official upon the recommendation of the Special Inspections Agency or upon review of the fabricator's written procedural and quality control manuals and periodic auditing of fabrication practices.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.01 PRE-INSPECTION MEETING

At least two weeks prior to beginning work, a Pre-inspection Meeting shall be held to discuss the Special Inspection procedures and submittals. The following parties shall participate: the Engineer, a Special Inspections Agency representative, the Contractor, Subcontractors, Testing Agencies, and the Building Official. The type of meeting (in-person or teleconference) and location of meeting shall be determined by the Building Official.

3.02 STATEMENT AND SCHEDULE OF SPECIAL INSPECTIONS

The Special Inspections Agency and all Special Inspectors are required to comply with all requirements of the Statement of Special Inspections and the Schedule of Special Inspections. Together, these documents identify materials, systems, components, and work that are required to have Special Inspections, the type and extent of Special Inspections, and whether they will be continuous or periodic.

3.03 SPECIAL INSPECTIONS AGENCY REQUIREMENTS AND RESPONSIBILITIES

A. The Special Inspections Agency shall be an established and recognized agency regularly engaged in conducting tests or furnishing inspection services, which has been approved by the Building Official and is retained by the Owner. The Agency shall demonstrate competence, to the satisfaction of the Building Official, for the inspection of the particular type of construction or operation requiring Special Inspection.

B. The Special Inspections Agency shall maintain detailed inspection records, including a copy at the jobsite, and all records shall be available upon request by the Engineer or the Building Official. The Agency shall submit all required reports to the Engineer and Building Official. Where Engineer approval is required for corrections, the Special Inspector shall maintain copies of all related correspondence and submit with all required reports. The Agency shall coordinate all required Special Inspection activities with the Special Inspectors, the Contractor, and any fabricators and shall coordinate designation of fabricators as Approved Fabricators when requested.

3.04 SPECIAL INSPECTORS' REQUIREMENTS AND RESPONSIBILITIES

A. All Special Inspectors shall meet the qualification requirements determined by the Building Official for the particular type of inspection services they will be providing and shall be approved by the Building Official. Special Inspectors shall submit written documentation demonstrating their competence and experience or training to the Building Official for approval of their qualifications.

B. Special Inspections shall be performed in accordance with all requirements of the Statement of Special Inspections, the Schedule of Special Inspections, the SCBC, and any State or local amendments. Special Inspectors shall maintain detailed inspection records, including a copy at the jobsite, and all records shall be available upon request by the Engineer or the Building Official. Special Inspectors shall submit all required reports to the Engineer and the Building Official. Where Engineer approval is required for corrections, the Special Inspector shall maintain copies of all related correspondence and submit with all required reports. Special Inspectors shall coordinate inspection requirements and timing with the Contractor.

C. Any discrepancies in work noted by the Special Inspector shall be brought to the immediate attention of the Contractor for correction. Special Inspectors shall coordinate correction of discrepancies with the Contractor. Any corrections of discrepancies that result in changes to the work as shown on the Contract Documents shall be approved by the Engineer. If noted discrepancies are not corrected, the Special Inspector shall notify the Contractor, the Engineer, and the Building Official. All noted discrepancies and corrections shall be documented in all inspection records and all required reports.

3.05 CONTRACTOR RESPONSIBILITIES

A. Each Contractor responsible for the construction or fabrication of a main wind- or seismic-force-resisting system, designated seismic system, or a wind- or seismic-resisting-component listed in the Statement of Special Inspections shall submit a Statement of Responsibility to the Building Official and Engineer prior to the commencement of work. The Statement of Responsibility shall contain acknowledgement of the special requirements contained in the Statement of Special Inspections.

B. The Contractor shall coordinate requirements of Special Inspections with the Special Inspections Agency and the Special Inspectors and shall provide adequate time and access to conduct inspections. The Contractor is solely responsible for providing safe access and any necessary safety equipment required to conduct inspections. The Special Inspector shall not supervise, direct, control, or have authority over or be responsible for the Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of the Contractor to comply with Laws and Regulations applicable to the performance of the Work.

C. Special Inspections shall not relieve the Contractor's obligation to perform and complete work in accordance with the Contract Documents. Results of Special Inspections activities, including any discrepancies that are noted or not noted, shall never constitute an acceptance of work that is not in accordance with the Contract Documents.

D. The Contractor shall provide advance notice of work to be conducted that will require Special Inspections. If the Special Inspector is delayed in inspecting the work due to inadequate notice or completion of the work, the Contractor shall reimburse the Owner for the cost of additional subsequent Special Inspections.

E. The Contractor shall promptly correct any discrepancies noted by the Special Inspectors. Any corrections of discrepancies that result in changes to the work as shown on the Contract Documents shall be approved by the Engineer. Where Engineer approval is required, the Contractor shall report the discrepancy to the Engineer in accordance with provisions of the General Conditions. The Engineer will authorize any changes to the Contract Documents required for the correction in accordance with provisions of the General Conditions. Copies of all correspondence related to the correction shall be submitted concurrently to the Special Inspections Agency.

3.06 BUILDING OFFICIAL OR AUTHORITY RESPONSIBILITIES

The Building Official will approve qualifications of the Special Inspections Agency, all Special Inspectors, and any Approved Fabricators. The Building Official will approve all forms submitted by the Contractor, any Approved Fabricators, the Engineer, the Special Inspections Agency, and the Special Inspectors. The Building Official and the Special Inspections Agency shall agree to the frequency of Interim Reports and the submittal deadline for the Final Report.

3.07 ENGINEER RESPONSIBILITIES

The Engineer shall complete the Statement of Special Inspections and the Schedule of Special Inspections. The Engineer shall respond to discrepancies noted by the Special Inspector, if required.

3.08 OWNER RESPONSIBILITES

The Owner will retain a Special Inspections Agency to perform Special Inspections during construction.

3.09 MINIMUM INSPECTION REQUIREMENTS

Detailed requirements for Special Inspections are shown in the Statement of Special Inspections and the Schedule of Special Inspections, which references the SCBC, applicable code standards, and any State or local amendments. Special Inspections shall be performed in accordance with all requirements of the Statement of Special Inspections, the Schedule of Special Inspections, the SCBC, and any State or local amendments. Additional requirements for specific materials listed in other sections of these specifications shall also be satisfied. The frequency of inspections shall be continuous or periodic as indicated in the Schedule of Special Inspections and in accordance with applicable building codes.

3.10 DISCREPANCIES AND CORRECTIVE MEASURES

A. The Special Inspector shall bring any discrepancies to the immediate attention of the Contractor for correction. The Contractor shall promptly correct any discrepancies noted by the Special Inspectors. Special Inspectors shall coordinate correction of discrepancies with the Contractor. Discrepancies and their correction shall be noted in inspection records and in all required reports. Any corrections that result in changes to the work as shown on the Contract Documents shall be approved by the Engineer. Where Engineer approval is required, the Contractor shall report the discrepancy to the Engineer in accordance with provisions of the General Conditions. The Engineer will authorize any changes to the Contract Documents required for the correction in accordance with provisions of the General Conditions. Copies of all correspondence related to the correction shall be submitted concurrently to the Special Inspections Agency.

B. If discrepancies are not corrected promptly, the Special Inspector shall notify the Contractor, the Engineer, and the Building Official using the attached form “Notification of Failure to Correct Discrepancies.”

3.11 REPORTS

Special Inspectors shall maintain detailed inspection records, including a copy at the jobsite, and all records shall be available upon request by the Engineer or the Building Official. The Special Inspections Agency shall submit all required reports to the Building Official and Engineer as agreed upon with the Building Official. Reports shall indicate the inspections and testing performed and whether work inspected was or was not completed in conformance to Contract Documents and any corrective measures taken. Where Engineer approval is required for corrections, the Agency shall maintain copies of all related correspondence and submit with all required reports.

STATEMENT OF SPECIAL INSPECTIONS

PROJECT: _____
LOCATION: _____
PERMIT APPLICANT: _____
APPLICANT'S ADDRESS: _____
ARCHITECT OF RECORD: _____
STRUCTURAL ENGINEER OF RECORD: _____
MECHANICAL ENGINEER OF RECORD: _____
ELECTRICAL ENGINEER OF RECORD: _____
REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE: _____

This Statement of Special Inspections is submitted in accordance with Section 1705 of the 2009 South Carolina Building Code. It shall be considered in conjunction with the Schedule of Special Inspections included in the Contract Documents. If applicable, it includes *Requirements for Seismic Resistance* and/or *Requirements for Wind Resistance*.

Are *Requirements for Seismic Resistance* included in the *Statement of Special Inspections*? ☐ Yes ☐ No

Are *Requirements for Wind Resistance* included in the *Statement of Special Inspections*? ☐ Yes ☐ No

The Special Inspector(s) shall keep detailed records of all inspections, including a copy at the jobsite. All records shall be available upon request by the Engineer or the Building Official. Any discrepancies shall be brought to the immediate attention of the Contractor. The Special Inspections Agency shall furnish Interim Reports to the Building Official and to the Engineer at the frequency indicated in the Statement of Special Inspections. A Final Report shall be submitted to the Building Official and the Engineer at the time agreed upon by the Owner and the Building Official.

Frequency of Interim Report submittals to the Building Official and the Engineer:
Weekly Bi-Weekly Monthly Other; specify:_____

Special Inspections do not relieve the Contractor of the obligation to comply with the Contract Documents. Jobsite safety and means and methods of construction are solely the responsibility of the Contractor.

Statement of Special Inspections Prepared by:

_____
Type or print name

_____
Signature Date

Registered Design Professional's Seal

Building Official's Acceptance:

_____
Signature Date

_____
Permit Number:

Statement of Special Inspections
Requirements for Seismic Resistance

See the Schedule of Special Inspections for inspection and testing requirements.

Seismic Design Category: _

Statement of Special Inspection for Seismic Resistance Required (Yes/No): _____

Description of seismic force-resisting system subject to special inspection and testing for seismic resistance:
(Required for Seismic Design Categories C, D, E or F)

Description of designated seismic systems subject to special inspection and testing for seismic resistance:
(Required for architectural, electrical and mechanical systems and their components that require design in accordance with Chapter 13 of ASCE 7, have a component importance factor, Ip, greater than one and are in Seismic Design Categories D, E or F.)

Description of additional seismic systems and components requiring special inspections and testing:
(Required for systems noted in SCBC Section 1705.3, cases 3, 4 & 5 in Seismic Design Categories C, D, E or F.)

Statement of Responsibility:
Each Contractor responsible for the construction or fabrication of a system or component described above must submit a Statement of Responsibility.

Statement of Special Inspections
Requirements for Wind Resistance

See the Schedule of Special Inspections for inspection and testing requirements

Basic Wind Speed (3 second gust): _____m.p.h.

Wind Exposure Category: _

Statement of Special Inspection for Wind Resistance Required (Yes/No): _____
(Required in wind exposure Category B, where the basic wind speed is 120 miles per hour or greater. Required in wind exposure Category C or D, where the basic wind speed is 110 miles per hour or greater)

Description of main wind force-resisting system subject to special inspection for wind resistance:

Description of wind force-resisting components subject to special inspection for wind resistance:

Statement of Responsibility:
Each Contractor responsible for the construction or fabrication of a system or component described above must submit a Statement of Responsibility.

INTERIM REPORT OF SPECIAL INSPECTIONS

City/County of:							
Project Name/Address:		Inspection Type(s) Coverage:					
		☐ Continuous			☐ Periodic		
Describe Inspections Made, Including Locations:							
Tests Made:							
Total Inspection Time Each Day	Date:						
	Hours:						
List items requiring Special Inspection, and any discrepancies and corrections. If Engineer approval is required for any corrections, note this, and indicate that approval was obtained. Attach copies of all related correspondence.							
Comments:							

To the best of my knowledge, work inspected was in accordance with the Contract Documents and applicable standards except as noted above.

Signed: _____ Date: _____

Print Full Name: _____ I.D. _____

Phone Number: _____

This report is to be submitted to the Building Official and the Engineer. A copy shall be maintained at the jobsite.

FINAL REPORT OF SPECIAL INSPECTIONS

PROJECT: _____
LOCATION: _____
PERMIT APPLICANT: _____
APPLICANT'S ADDRESS: _____

_____
ARCHITECT OF RECORD: _____
STRUCTURAL ENGINEER OF RECORD: _____
MECHANICAL ENGINEER OF RECORD: _____
ELECTRICAL ENGINEER OF RECORD: _____
REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE: _____

To the best of my information, knowledge, and belief, Special Inspections required for this Project in accordance with Section 1705 of the 2009 South Carolina Building Code and any State or local amendments have been performed, and all work has been completed in accordance with the Contract Documents and all applicable standards, except as indicated.

The Special Inspection program does not relieve the Contractor of the obligation to comply with the Contract Documents. Jobsite safety and means and methods of construction are solely the responsibility of the Contractor.

This Final Report includes information submitted in previous Interim Reports numbered to ____, as well as any Special Inspections, discrepancies, and corrections occurring since the last Interim Report, dated ____.

All items requiring Special Inspection are listed below. All inspections, tests, and similar services that were performed are listed and any discrepancies and corrections are indicated. If Engineer approval was required for any corrections, this is noted, and copies of all related correspondence are attached.

_____
_____
_____
_____
_____

(Attach 8 ½"x11" continuation sheet(s) if required to complete the description of corrections)

Special Inspector's Seal

Prepared By:

_____
Special Inspection Agency

_____
Type or print name

_____
Signature Date

CONTRACTOR'S STATEMENT OF RESPONSIBILITY

Each Contractor responsible for the construction or fabrication of a main-wind- or seismic-force-resisting system, designated seismic system, or a wind- or seismic-resisting-component listed in the Statement of Special Inspections must submit this Statement of Responsibility prior to commencement of work on the system or component.

Project: _____

Contractor's Name: _____

Address: _____

License No.: _____

Description of building systems and components included in Statement of Responsibility:

_____
_____
_____
_____
_____
_____
_____

Contractor's Acknowledgement of Special Requirements

I hereby acknowledge that I have received, read, and understand the Statement of Special Inspections and its requirements.

_____
Name and Title (type or print)

_____ _____
Signature Date

FABRICATOR'S CERTIFICATE OF COMPLIANCE

Each approved fabricator that is exempt from Special Inspection of shop fabrication and implementation procedures per section 1704.2.2 of the 2009 South Carolina Building Code must submit this Fabricator's Certificate of Compliance at the completion of fabrication.

Project: _____

Fabricator's Name: _____

Address: _____

Description of structural members and assemblies that have been fabricated:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

I hereby certify that items described above were fabricated on my premises in strict accordance with the Contract Documents and applicable standards.

_____
Name and Title (type or print)

_____ _____
Signature Date

Attach copy of Building Official's approval of fabricator as an Approved Fabricator.

NOTIFICATION OF FAILURE TO CORRECT DISCREPANCY

City/County of:
Project name/Address:
List discrepancies, proposed correction, and Contractor response. If Engineer approval is required for any corrections, note this, and indicate whether approval was obtained. Attach copies of all related correspondence.
Comments:

Signed: _____ Date: _____

Print Full Name: _____ I.D. _____

Phone Number: _____

This report is to be submitted to the Building Official, the Contractor, and the Engineer.

SECTION 01510

TEMPORARY UTILITIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The General Contractor shall provide temporary light and power, heating, water service and sanitary facilities for his operations, for the construction operations of the other Contractors of this Project at the site, with the exception that the utility company service charge for use of temporary aerators and bypass pumps shall be paid by the Owner. The temporary services shall be provided for use as required throughout the construction period.

B. The General Contractor shall coordinate and install all temporary services in accordance with the requirements of the utility companies having jurisdiction and as required by applicable codes and regulations.

C. At the completion of the work, or when the temporary services are no longer required, the facilities shall be restored to their original conditions.

D. All costs in connection with the temporary services including, but not limited to, installation, utility company service charges (with the exception of the temporary aerators and bypass pumps (if electric)), maintenance, relocation and removal shall be borne by the Contractor at no additional cost to the Owner.

E. Some temporary facilities that may be required may be indicated on the Drawings; however, the Drawings do not necessarily show any or all of the temporary facilities that the Contractor ultimately uses to complete the work.

F. Temporary Light and Power

1. The temporary general lighting and small power requirements shall be serviced by 120/240 V, 1 phase, 3 wire temporary systems furnished and installed by the General Contractor. This service shall be furnished complete with main disconnect, overcurrent protection, meter outlet, branch circuit breakers, and wiring as required; including branch circuit breakers and wiring as required for furnishing temporary power to the various Contractor's field office service connections, all in accordance with the requirements of the servicing power company and applicable standards and codes. The meter for the temporary 120/240 V service for construction purposes shall be registered in the name of the General Contractor and all energy charges for furnishing this temporary electric power shall be borne by the General Contractor. Any Contractor with a need for power other than the 120/240 V, 1 phase, 3 wire shall provide such power at his own expense.

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2. The General Contractor shall make all necessary arrangements, and pay for all permits, inspections, and power company charges for all temporary service installations. All temporary systems shall comply with and meet the approval of the local authorities having jurisdiction. All temporary electrical systems shall consist of wiring, switches, necessary insulated supports, poles, fixtures, sockets, receptacles, lamps, guards, cutouts, and fuses as required to complete such installations. The General Contractor shall furnish lamps and fuses for all temporary systems furnished by him and shall replace broken and burned out lamps, blown fuses, damaged wiring and as required to maintain these systems in adequate and safe operating condition. All such temporary light and power system shall be installed without interfering with the work of the other Contractors.

   When it is necessary during the progress of construction that a temporary electrical facility installed under this Division interferes with construction operations, the General Contractor shall relocate the temporary electrical facilities to maintain temporary power as required at no additional cost to the Owner. The General Contractor shall be responsible at all times for any damage or injury to equipment, materials, or personnel caused by improperly protected or installed temporary installations and equipment.

3. The various Contractors doing the work at the site shall be permitted to connect into the temporary general lighting system small hand tools, such as drills, hammers, and grinders, provided that:

   a. Equipment and tools are suitable for 120 V, single phase, 60 Hz operation and operating input does not exceed 1,500 volt-amperes.

   b. Tools are connected to outlets of the system with only one (1) unit connected to a single outlet.

   c. In case of overloading of circuits, the General Contractor will restrict use of equipment and tools as required for correct loading.

4. The General Contractor shall keep the temporary general lighting and power systems energized fifteen minutes before the time that the earliest trade starts in the morning and de-energized fifteen minutes after the time the latest trade stops. This applies to all weekdays, Monday through Friday, inclusive, which are established as regular working days.

   Any Contractor requiring temporary light and power before or after the hours set forth hereinbefore, or on a Saturday, Sunday, or holiday, shall pay for the additional cost of keeping the system energized and repaired. If more than one Contractor is involved, the charges shall be prorated, such amounts to be determined from the meter readings or other acceptable means previously agreed upon by the Contractors involved. If it is necessary for any Contractor or his employees to be in any structure after regular working hours and the temporary general lighting system is not required for illumination, that Contractor shall provide such illumination required by means of flashlights, electric lanterns, or other devices not requiring use of electricity from the temporary general lighting system.

5. Each Contractor requiring additional power and lighting other than that specified herein (including power for temporary heating equipment to be provided by the General Contractor) shall furnish his own service complete with all fuses, cutouts, wiring and other material and equipment necessary for a complete system between the service point and the additional power consumers and shall install his own metering equipment in accordance with the requirements of the servicing power company.

6. The temporary general lighting system shall be installed progressively in structures as the various areas are enclosed or as lighting becomes necessary because of partial enclosure. Lighting intensities shall be not less than 10 foot candles.

7. The General Contractor shall provide a separate temporary night lighting circuit for construction security. This system shall be energized at the end of each normal working day and de-energized at the start of each normal working day by the General Contractor. The system is to be left energized over Saturdays, Sundays, and all holidays. Lighting intensities shall be not less than 2 foot candles.

8. Electrical welders provided by each trade used in the erection and fabrication of the buildings, structures and equipment shall be provided with an independent grounding cable connected directly to the structure on which the weld is being made rather than adjacent conduit piping, etc.

   Electricians and other tradesmen necessary for the required connections and operation of welding equipment and generator, standby generators and similar equipment shall be furnished by the individual Contractors. All costs for such labor and equipment shall be borne by the individual Contractors.

9. Upon completion of the work, but prior to acceptance by the Owner, the General Contractor shall remove all temporary services, security lighting systems, temporary general lighting systems and all temporary electrical work from the premises.

G. Temporary Heating

1. The General Contractor shall provide temporary heating, ventilation coverings and enclosures necessary to properly protect all work and materials against damage by dampness and cold, to dry out the work and to facilitate work in all structures.

2. The equipment, fuel, materials, operating personnel and methods used shall be at all times satisfactory and adequate to maintain critical installation temperatures and ventilation for all work in those areas where the same is required.

3. After any structure is enclosed, the minimum temperature to be maintained is 50°F, unless otherwise specified, where work is actually being performed.

4. Before and during the application of interior finishing, painting, etc., the General Contractor shall provide sufficient heat to maintain a temperature of not less than 65°F.

5. Any work damaged by dampness or insufficient or abnormal heating shall be replaced by the General Contractor at no additional cost to the Owner.

H. Temporary Sanitary Service

1. Sanitary conveniences, in sufficient numbers, for the use of all persons employed on the work and properly screened from public observation, shall be provided and maintained at suitable locations by the General Contractor, all as prescribed by State Labor Regulations and local ordinances. The contents of same shall be removed and disposed of in a manner consistent with local and state regulations, as the occasion requires. Each Contractor shall rigorously prohibit the committing of nuisances within, on, or about the work. Sanitary facilities shall be removed from the site when no longer required.

I. Temporary Water

1. The General Contractor shall provide temporary water service for construction purposes, sanitary facilities, fire protection, field offices and for cleaning. The Contractor shall make all arrangements for connections to the potable water at the plant site.

   The Contractor shall pay all charges associated with the connection and all charges for potable water used under this Contract.

2. Each Contractor shall supply potable water for his employees either by portable containers or drinking fountains.

3. An adequate number of hose bibbs, hoses, and watertight barrels shall be provided for the distribution of water.

4. Water service shall be protected from freezing and the service shall be extended and relocated as necessary to meet temporary water requirements.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01520

MAINTENANCE OF UTILITY OPERATIONS DURING CONSTRUCTION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The existing plant will be maintained in continuous operation by the Owner during the entire construction period of all Contracts as hereinafter specified. The intent of this section is to outline the minimum requirements necessary to allow the Owner to continuously operate and maintain the treatment facility in order to remain in compliance with all permit requirements.

B. Work under each Contract shall be scheduled and conducted by each Contractor so as not to impede any treatment process, reduce the quality of the plant effluent or cause odor or other nuisance except as explicitly permitted hereinafter. In performing the work shown and specified, the Contractor shall plan and schedule his work to meet the plant and collection system operating requirements, and the constraints and construction requirements as outlined in this Section. No discharge of raw or inadequately treated wastewater shall be allowed. The Contractor shall pay all civil penalties, costs, assessments, etc., associated with any discharge of raw or inadequately treated wastewater associated with the Contractor's work.

C. The General Contractor shall be responsible for coordinating the general construction and electrical, HVAC and plumbing construction schedules and for ensuring that permanent or temporary power is available for all existing, proposed, and temporary facilities that are required to be on line at any given time.

D. The Contractor has the option of providing additional temporary facilities that can eliminate a constraint, provided it is done without cost to the Owner and provided that all requirements of these Specifications are fulfilled. The Contractor shall submit any such plan for providing additional temporary facilities to eliminate a constraint to the PM for review. Such plans must be approved by the Engineer and Owner prior to the Contractor proceeding. Work not specifically covered in the following paragraphs may, in general, be done at any time during the contract period, subject to the operating requirements and constraints and construction requirements outlined hereinafter. All references to days in this Section shall be consecutive calendar days.

1.02 GENERAL CONSTRAINTS

A. The Contractor shall schedule the Work so that the plant is maintained in continuous operation. All treatment processes shall be maintained in continuous operation during the construction period except during approved process interruptions. All short-term system or partial systems shutdowns and diversions shall be approved by the Engineer. Long-term process shutdowns and diversions shall conform to the requirements hereinafter specified and shall be minimized by the Contractor as much as possible. If in the judgement of the Engineer a requested shutdown is not required for the Contractor to perform the Work, the Contractor shall utilize approved alternative methods to accomplish the Work. All shutdowns

shall be coordinated with and scheduled at times suitable to the Owner. Shutdowns shall not begin until all required materials are on hand and ready for installation. Each shutdown period shall commence at a time approved by the Owner, and the Contractor shall proceed with the Work continuously, start to finish, until the Work is completed and normal plant operation is restored. If the Contractor completes all required Work before the specified shutdown period has ended, the Owner may immediately place the existing system back into service.

B. The Contractor shall schedule short-term and long-term shutdowns in advance and shall present all desired shutdowns in the 30 and 60-day schedules at the progress meetings (see Section 01200). Shutdowns shall be fully coordinated with the Plant Superintendent at least 48 hours before the scheduled shutdown. Owner personnel shall operate Owner's facilities involved in the short-term and long-term shutdowns and diversions.

C. Short term shutdowns in plant flow will be allowed for tie-ins to existing facilities, installation of temporary bulkheads, etc. All such shutdowns shall be scheduled for week-end low-flow periods and shall be limited to less than two (2) hours depending on incoming flow rate and storage volume in the collection and treatment system. Any shutdown of two (2) hours or longer duration shall be defined as a long-term shutdown. The Contractor shall provide appropriate diversion facilities to be approved by the Owner, and at no additional cost to the Owner, when the plant cannot be shut down for a sufficient long time to accomplish the required work. The Contractor may be allowed additional time for short-term interruptions if he can demonstrate to the Owner and Engineer that the collection system will not surcharge or overflow during the requested shutdown period. Duration of short-term interruptions allowed will depend on incoming wastewater flow rate and prevention of any discharge of raw wastewater from the collection system. The schedule and duration of short-term shutdowns shall be at the discretion of the Owner.

D. Any temporary work, facilities, roads, walks, protection of existing structures, piping, blind flanges, valves, equipment, etc. that may be required within the Contractor's work limits to maintain continuous and dependable plant operation shall be furnished by the Contractor at the direction of the Engineer at no extra cost to the Owner.

E. The Owner shall have the authority to order Work stopped or prohibited that would, in his opinion, unreasonably result in interrupting the necessary functions of the plant operations.

F. If the contractor impairs performance or operation of the plant as a result of not complying with specified provisions for maintaining plant operations, then the contractor shall immediately make all repairs or replacements and do all work necessary to restore the plant to operation to the satisfaction of the Engineer. Such work shall progress continuously to completion on a 24-hours per day, seven work days per week basis.

G. The Contractor shall provide the services of emergency repair crews on call 24-hours per day to affect repairs to portions of the plant affected by the Contractor’s operations.

1.03 GENERAL OPERATING REQUIREMENTS, CONSTRAINTS, AND CONSTRUCTION REQUIREMENTS

A. Access to Plant Site, Roadways, and Parking Areas

1. An unobstructed traffic route through the Main Gate shall be maintained at all times for the Owner's operations personnel and maintenance equipment. Parking for personal vehicles of construction personnel shall not be allowed within the fence of the treatment plant. Construction personnel may park on City property outside the plant fence in areas approved by the Engineer. The General Contractor shall be responsible for providing access to and for preparing and maintaining/approved parking areas.

2. An unobstructed traffic route around the plant site shall be maintained at all times for the Owner's operations personnel and maintenance equipment. Vehicular access to the treatment units and buildings for Owner personnel shall be maintained at all times by the Contractor.

3. The Contractor shall provide temporary measures to protect the existing pavement by filling over with earthen material or supplying other measures acceptable to the Engineer, and he shall repair any damage to existing paved surfaces that occurs during the construction period. Any areas disturbed along the shoulders of the access road and interior roads and elsewhere inside and outside of the plant shall be repaired, graded, seeded, etc. as necessary to match pre-existing conditions.

4. The General Contractor shall not undertake the restoration/construction of new roadway (paved, gravel, or asphalt overlay) shown on the Contract Drawings, until all other work on the plant improvements has been completed.

B. Personnel Access

1. Treatment plant personnel shall have access to all areas which remain in operation throughout the construction period. The Contractor shall locate stored material, dispose of construction debris and trash, provide temporary walkways, provide temporary lighting, and other such work as directed by the Engineer to maintain personnel access to areas in operation. Access and adequate parking areas for plant personnel must be maintained throughout construction.

C. Plumbing Facilities

1. Unless otherwise allowed by the Engineer, sanitary facilities in the existing structures shall be operational at all times for plant operating personnel. All other building plumbing systems such as roof and floor drains, pumping, etc., shall be maintained for all structures.

D. Building Heating and Ventilating

1. Building heating and ventilating for the existing plant structures shall be in service for the entire construction period. Additional temporary heating and ventilation shall be provided as required to maintain facilities under construction adequately heated and vented. The temperatures to be maintained in any areas occupied by plant operating personnel such as offices, lunchrooms, locker rooms, bathrooms, etc., shall be at least 65°F. The temperatures to be maintained in all other interior plant areas, whether new, existing or temporary, shall be maintained at a minimum of 55°F.

E. Power, Light and Communications Systems (General)

1. Electric power, lighting service and communications systems shall be maintained in uninterrupted operation in all areas which remain in operation. Individual units may be disconnected as required for replacement, but service shall be available at all times including periods when plant elements are out of service. Shutdown of electrical facilities shall be limited to not more than five (5) hours. The Owner may allow longer outages under conditions determined by the Owner by making use of the existing and/or the proposed engine-generator at the plant. All costs associated with operation of the engine-generators shall be paid by the Contractor. The Electrical Contractor shall coordinate shutdowns required with the General Contractor to minimize the total number of shutdowns required to complete construction. Owner's phone service to the plant shall be maintained in continuous operation during construction.

F. Draining Process Pipes and Conduits (General)

1. The contents of all pipes and conduits to be removed, replaced or relocated (or dewatered for a specific purpose) shall be transferred to a suitable facility in a manner approved by the Owner through hoses or piping, or by using pumps if hydraulic conditions so require them. The Contractor shall provide the pumps, piping and hoses at no additional cost to the Owner. No uncontrolled spillage of a pipe or conduit shall be permitted. Any spillage, other than potable water, shall be immediately washed down and flushed into the appropriate process flow train.

G. Potable Water System

1. Potable water service shall be maintained in continuous service at all times during construction except for short term interruptions required for tie-ins. Shutdown of the potable water system shall be fully planned and coordinated with the Plant Superintendent and shall be limited to not more than two (2) hours. Existing fire hydrants within the plant site shall be operational at all times, unless otherwise approved by the Owner.

H. Non-potable Water System

1. The existing non-potable water service shall be maintained in continuous operation during construction except for short term tie-ins of new or temporary facilities to existing facilities, until the new system is brought into service. Temporary non-potable service for the chlorine and pump seal water systems shall be provided by the Contractor as necessary to insure continuous, uninterrupted service of these critical systems. The Contractor shall furnish any required temporary non-potable water systems at no additional cost to the Owner. The Contractor may require temporary support or relocation or demolition of existing non-potable water facilities to proceed with construction The Contractor shall provide all temporary supports, relocation of existing piping, or demolition of existing non-potable water piping including placement with temporary or permanent non-potable water piping as required at no additional cost to the Owner. Shutdown of the non-potable water system shall be fully coordinated with the Plant Superintendent and shall be limited to not more than five (5) hours.

I. Sump Pumps and Sumps

1. All existing sumps shall be maintained in an operable condition with either existing pumps or temporary pumps. Interim piping, power and controls shall be provided as required by the staged construction sequence.

J. Seal Water and Service Water Piping

1. A supply of service and seal water and the necessary connections to existing equipment shall be maintained during construction. Interim piping shall be provided as required.

1.04 SPECIFIC OPERATIONAL CONSTRAINTS

A. The respective Contractors shall schedule the work for the following based on the constraints given in such a manner as to maintain the wastewater treatment plant in continuous operation.

1. Blower Facility

a. The new blower facility shall be constructed in parallel to improvements to the aeration tanks and air piping. All electrical associated with the new blower facility, including the Blower Electrical Power Center shall be operational prior to the blower facility being operational.

b. Improvements to potable water, non-potable water, and sanitary sewer piping adjacent to the Blower Facility shall be completed prior to placement of concrete for the Blower Facility. Completion shall include relocation in accordance to the plans and testing of all piping in accordance with the requirements of these specifications.

c. Blower facility shall be operated for a successful 14 day continuous performance test prior to removal of the existing blower facility from service.

2. Aeration Tanks and Air Piping

a. Two aeration tanks (Aeration Tank No 1 and No 2) shall remain in service throughout construction except for the period required to modify each individual tank. One (1) aeration tank shall remain in service at all times during construction.

b. Aeration Tank No 1 shall be modified, start-up and successfully operate for 14 days prior to initiating construction on Aeration Tank No 2.

c. The Contractor shall schedule and coordinate construction activities such that improvements to Aeration Tank No 1 are completed soon after substantial completion of the Blower Facility and Blower Electrical Power Center to limit the amount of time Aeration Tank No 1 is out of service.

d. Additional Aeration Capacity During Construction

i. The Contractor shall provide supplemental aeration in Aeration Tank No. 2 during improvements to Aeration Tank No 1 at no additional cost to the Owner. The supplemental aeration system shall provide a minimum standard oxygen transfer rate of 19,400 pounds of oxygen per day (808 pounds of oxygen per hour). Temporary aeration shall be provided by eight Model TR40 floating aerators or six Model TR60 floating aerators as manufactured by Aeration Industries International. Alternative aeration equipment will be considered provided that it delivers an equivalent amount of oxygen to the process using similar power. Details of proposed temporary aeration equipment shall be submitted to the Owner and Engineer for approval. Sufficient information shall be included in the submittal including dimensional data, installation details, standard oxygen transfer rates (SOTR), documentation of standard oxygen transfer efficiency (SOTE), and power consumption.

ii. Temporary aeration shall be powered from the plant's existing 27kV loop via a fuse compartment within PMS-5. The Contractor shall provide all temporary power distribution equipment, including but not limited to: appropriate 27kV fuse, primary conduit/wire, outdoor unit substation equipped with a fused primary section, step-down transformer, and 480V power distribution switchboard section(s) as required to adequately supply the temporary equipment. Low Voltage conduit/wire, temporary aeration starters, and any miscellaneous electrical or control components required for a complete, operable, Code compliant temporary system. Refer to the Contract Drawings for additional information. As indicated on Sheet M03, Note 4: Adequate electrical service is not available to provide both temporary aeration and bypass pumping simultaneously.

e. Aeration Tank No 1 shall not be filled for startup and performance testing until the new Blower Facility, Blower Electrical Power Center and sufficient air piping to provide air to Tank No 1 is constructed, tested and operational. Performance testing requirements shall be provided in parallel to performance testing required in Section 1.04-A-1.

f. Mixer and diffuser testing shall be performed with plant effluent water prior to introduction of wastewater into tanks. The Owner shall provide plant effluent water at no charge to the Contractor. Contractor shall provide all equipment, including pumps, and shall pay all costs to pump plant effluent water from the Effluent Structure to the Aeration Tanks for field tests of the mixers at an appropriate flow rate to fill the Aeration Tank within 48 hours in coordination with field testing of the fine bubble aeration equipment. Connection to a plant effluent hydrant will not be acceptable. Tanks shall be filled to maximum water levels.

g. Aeration Tank No 1 shall be operated for a successful 14-day continuous performance test prior to taking the Aeration Tank No 2 out of service to begin modifications. Filling the tank with mixed liquor is considered the beginning of this performance test period. Prior to the Blower Facility performance test, the mixers and diffusers shall be tested with the tanks filled with plant effluent.

3. Junction Structure

a. Improvements to Junction Structure shall be completed without impacting flow from aeration tanks to final clarifiers.

b. Bypass pumping shall be provided to convey a total mixed liquor flow for the rated capacity of the plant for the duration of work on the Junction Structure improvements. The system shall be designed, submitted and provided in accordance with Specification 02665 of these specifications.

i. The bypass pumping shall maintain current operational flexibility to allow conveyance of flow to all final clarifiers in service while also allowing for removal of final clarifiers from service. System shall allow for an even distribution of flow to each clarifier within 5% from the lowest flow to highest flow to each clarifier.

ii. The bypass pumping system shall remain in use for the duration of work and shall remain on site until completion of a 10-day operational test of the Junction Structure improvements.

iii. Bypass pumping design shall include electrical requirements (as applicable) and shall be coordinated with the temporary electrical system provided for the temporary aeration equipment. Temporary electrical system shall be adequately sized to meet the requirements of all temporary systems provided by the Contractor for this project.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01530

PROTECTION OF EXISTING FACILITIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Contractor shall be responsible for the preservation and protection of property adjacent to the work site against damage or injury as a result of his operations under this Contract. Any damage or injury occurring on account of any act, omission or neglect on the part of the Contractor shall be restored in a proper and satisfactory manner or replaced by and at the expense of the Contractor to an equal or superior condition than previously existed.

B. Contractor shall comply promptly with such safety regulations as may be prescribed by the Owner or the local authorities having jurisdiction and shall, when so directed, properly correct any unsafe conditions created by, or unsafe practices on the part of, his employees. In the event of the Contractor's failure to comply, the Owner may take the necessary measures to correct the conditions or practices complained of, and all costs thereof will be deducted from any monies due the Contractor. Failure of the Engineer to direct the correction of unsafe conditions or practices shall not relieve the Contractor of his responsibility hereunder.

C. In the event of any claims for damage or alleged damage to property as a result of work under this Contract, the Contractor shall be responsible for all costs in connection with the settlement of or defense against such claims. Prior to commencement of work in the vicinity of property adjacent to the work site, the Contractor, at his own expense, shall take such surveys as may be necessary to establish the existing condition of the property. Before final payment can be made, the Contractor shall furnish satisfactory evidence that all claims for damage have been legally settled or sufficient funds to cover such claims have been placed in escrow, or that an adequate bond to cover such claims has been obtained.

1.02 PROTECTION OF WORK AND MATERIAL

A. During the progress of the work and up to the date of final payment, the Contractor shall be solely responsible for the care and protection of all work and materials covered by the Contract, except as provided for in 7.12 of the General Conditions.

B. All work and materials shall be protected against damage, injury or loss from any cause whatsoever, and the Contractor shall make good any such damage or loss at his own expense. Protection measures shall be subject to the approval of the Engineer.

1.03 BARRICADES, WARNING SIGNS AND LIGHTS

A. The General Contractor shall provide, erect and maintain as necessary, strong and suitable barricades, danger signs and warning lights along all roads accessible to the public, as required by the authority having jurisdiction, to insure safety to the public. All barricades and obstructions along public roads shall be illuminated at night and all lights for this purpose shall be kept burning from sunset to sunrise.

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B. Each Contractor shall provide and maintain such other warning signs and barricades in areas of and around their respective work as may be required for the safety of all those employed in the work, the Owner's operating personnel, or those visiting the site.

1.04 EXISTING UTILITIES AND STRUCTURES

A. The term existing utilities shall be deemed to refer to both publicly-owned and privately-owned utilities such as electric power and lighting, telephone, water, gas, storm drains, process lines, sanitary sewers and all appurtenant structures.

B. Where existing utilities and structures are indicated on the Drawings, it shall be understood that all of the existing utilities and structures affecting the work may not be shown and that the locations of those shown are approximate only. It shall be the responsibility of the Contractor to ascertain the actual extent and exact location of existing utilities and structures. In every instance, the Contractor shall notify the proper authority having jurisdiction and obtain all necessary directions and approvals before performing any work in the vicinity of existing utilities.

C. Prior to beginning any excavation work, the Contractor shall, through field investigations, determine any conflicts or interferences between existing utilities and new utilities to be constructed under this project. This determination shall be based on the actual locations, elevations, slopes, etc., of existing utilities as determined in the field investigations, and locations, elevation, slope, etc. of new utilities as shown on the Drawings. If an interference exists, the Contractor shall bring it to the attention of the Engineer as soon as possible. If the Engineer agrees that an interference exists, he shall modify the design as required. Additional costs to the Contractor for this change shall be processed through a Change Order as detailed elsewhere in these Contract Documents. In the event the Contractor fails to bring a potential conflict or interference to the attention of the Engineer prior to beginning excavation work, any actual conflict or interference which does arise during the Project shall be corrected by the Contractor, as directed by the Engineer, at no additional expense to the Owner.

D. The work shall be carried out in a manner to prevent disruption of existing services and to avoid damage to the existing utilities. Temporary connections shall be provided, as required, to insure uninterruption of existing services. Any damage resulting from the work of this Contract shall be promptly repaired by the Contractor at his own expense in a manner approved by the Engineer and further subject to the requirements of any authority having jurisdiction. Where it is required by the authority having jurisdiction that they perform their own repairs or have them done by others, the Contractor shall be responsible for all costs thereof.

E. Where excavations by the Contractor require any utility lines or appurtenant structures to be temporarily supported and otherwise protected during the construction work, such support and protection shall be provided by the Contractor. All such work shall be performed in a manner satisfactory to the Engineer and the respective authority having jurisdiction over such work. In the event the Contractor fails to provide proper support or protection to any existing utility, the Engineer may, at his discretion, have the respective authority to provide such support or protection as may be necessary to insure the safety of such utility, and the costs of such measures shall be paid by the Contractor.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 01540

DEMOLITION AND REMOVAL OF EXISTING STRUCTURES AND EQUIPMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. This Section covers the demolition, removal, and disposal of existing buildings, structures, pavement, curbs, and sidewalk, removal and disposal of asbestos materials, and any existing equipment including electrical, plumbing, heating and ventilating equipment and piping not required for the operation of the rehabilitated plant as indicated on the Drawings and as specified hereinafter. The Contractor shall furnish all labor, materials and equipment to demolish buildings and structures and to remove fixtures, anchors, supports, piping and accessories designated to be removed on the Drawings.

1.02 TITLE TO EQUIPMENT AND MATERIALS

A. Contractor shall have no right or title to any of the equipment, materials or other items to be removed from the existing buildings or structures unless and until said equipment, materials and other items have been removed from the premises. The Contractor shall not sell or assign, or attempt to sell or assign any interest in the said equipment, materials or other items until the said equipment, materials or other items have been removed.

B. Contractor shall have no claim against the Owner because of the absence of such fixtures and materials.

1.03 CONDITION OF STRUCTURES AND EQUIPMENT

A. The Owner does not assume responsibility for the actual condition of structures and equipment to be demolished and removed.

B. Conditions existing at the time of inspection for bidding purposes will be maintained by the Owner so far as practicable.

C. The information regarding the existing structures and equipment shown on the Drawings is based on visual inspection and a walk-through survey only. Neither the Engineer nor the Owner will be responsible for interpretations or conclusions drawn therefrom by the Contractor.

PART 2 -- PRODUCTS

(NOT USED)

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PART 3 -- EXECUTION

3.01 DEMOLITION AND REMOVALS

A. The removal of all equipment and piping, and all materials from the demolition of buildings and structure shall, when released by the Owner and Engineer, shall be done by the Contractor and shall become the Contractor's property, unless otherwise noted, for disposition in any manner not contrary to the Contract requirements and shall be removed from the site to the Contractor's own place of disposal.

B. The Electrical Contractor (Subcontractor) specifically, shall de-energize all panelboards, lighting fixtures, switches, circuit breakers, electrical conduits, motors, limit switches, pressure switches, instrumentation such as flow, level and/or other meters, wiring, and similar power equipment prior to removal. Any electric panels or equipment which are to be retained shall be relocated or isolated by the Electrical Contractor (Subcontractor) specifically, prior to the removal of the equipment specified herein.

C. The Contractor shall proceed with the removal of the equipment, piping and appurtenances in a sequence designed to maintain the plant in continuous operation as described in Section 01520, Maintenance of Utility Operations During Construction, and shall proceed only after approval of the Engineer.

D. Any equipment piping and appurtenances removed without proper authorization, which are necessary for the operation of the existing facilities shall be replaced to the satisfaction of the Engineer at no cost to the Owner.

E. Excavation caused by demolitions shall be backfilled with fill free from rubbish and debris.

3.02 PROTECTION

A. Demolition and removal work shall be performed by competent experienced workmen for the various type of demolition and removal work and shall be carried out through to completion with due regard to the safety of Owner employees, workmen on-site and the public. The work shall be performed with as little nuisance as possible.

B. The work shall comply with the applicable provisions and recommendation of ANSI A10.2, Safety Code for Building Construction, all governing codes, and as hereinafter specified.

C. The Contractor shall make such investigations, explorations and probes as are necessary to ascertain any required protective measures before proceeding with demolition and removal. The Contractor shall give particular attention to shoring and bracing requirements so as to prevent any damage to new or existing construction.

D. The Contractor shall provide, erect, and maintain catch platforms, lights, barriers, weather protection, warning signs and other items as required for proper protection of the public, occupants of the building, workmen engaged in demolition operations, and adjacent construction.

E. The Contractor shall provide and maintain weather protection at exterior openings so as to fully protect the interior premises against damage from the elements until such openings are closed by new construction.

F. The Contractor shall provide and maintain temporary protection of the existing structure designated to remain where demolition, removal and new work is being done, connections made, materials handled or equipment moved.

G. The Contractor shall take necessary precautions to prevent dust from rising by wetting demolished masonry, concrete, plaster and similar debris. Unaltered portions of the existing buildings affected by the operations under this Section shall be protected by dust-proof partitions and other adequate means.

H. The Contractor shall provide adequate fire protection in accordance with local Fire Department requirements.

I. The Contractor shall not close or obstruct walkways, passageways, or stairways and shall not store or place materials in passageways, stairs or other means of egress. The Contractor shall conduct operations with minimum traffic interference.

J. The Contractor shall be responsible for any damage to the existing structure or contents by reason of the insufficiency of protection provided.

3.03 WORKMANSHIP

A. The demolition and removal work shall be performed as described in the Contract Documents. The work required shall be done with care, and shall include all required shoring, bracing, etc. The Contractor shall be responsible for any damage which may be caused by demolition and removal work to any part or parts of existing structures or items designated for reuse or to remain. The Contractor shall perform patching, restoration and new work in accordance with applicable Technical Sections of the Specifications and in accordance with the details shown on the Drawings. Prior to starting of work, the Contractor shall provide a detailed description of methods and equipment to be used for each operation and the sequence thereof for review by the Engineer.

B. All supports, pedestals and anchors shall be removed with the equipment and piping unless otherwise specified or required. Concrete bases, anchor bolts and other supports shall be removed to approximately 1-inch below the surrounding finished area and the recesses shall be patched to match the adjacent areas. Superstructure wall and roof openings shall be closed, and damaged surfaces shall be patched to match the adjacent areas, as specified under applicable Sections of these Specifications, as shown on the Drawings, or as directed by the Engineer. Wall sleeves and castings shall be plugged or blanked off, all openings in concrete shall be closed in a manner meeting the requirements of the appropriate Sections of these Specifications, as shown on the Drawings, and as directed and approved by the Engineer.

C. Materials or items designated to remain the property of the Owner shall be as hereinafter tabulated. Such items shall be removed with care and stored at a location at the site to be designated by the Owner.

D. Where equipment is shown or specified to be removed and relocated, the Contractor shall not proceed with removal of this equipment without specific prior approval of the Engineer. Upon approval, and prior to commencing removal operations, the equipment shall be operated in the presence of representatives of the Contractor, Owner and Engineer. Such items shall be removed with care, under the supervision of the trade responsible for reinstallation and protected and stored until required. Material or items damaged during removal shall be replaced with similar new material or item. Any equipment that is removed without proper authorization and is required for plant operation shall be replaced at no cost to the Owner.

E. Wherever piping is to be removed for disposition, the piping shall be drained by the Contractor and adjacent pipe and headers that are to remain in service shall be blanked off or plugged and then anchored in an approved manner.

F. Materials or items demolished and not designated to become the property of the Owner or to be reinstalled shall become the property of the Contractor and shall be removed from the property and legally disposed of.

G. The Contractor shall execute the work in a careful and orderly manner, with the least possible disturbance to the public and to the occupants of the building.

H. In general, masonry shall be demolished in small sections, and where necessary to prevent collapse of any construction, the Contractor shall install temporary shores, struts, and bracing.

I. Where alterations occur, or new and old work join, the Contractor shall cut, remove, patch, repair or refinish the adjacent surfaces to the extent required by the construction conditions, so as to leave the altered work in as good a condition as existed prior to the start of the work. The materials and workmanship employed in the alterations, unless otherwise shown on the Drawing or specified, shall comply with that of the various respective trades which normally perform the particular items or work.

J. The Contractor shall finish adjacent existing surfaces to new work to match the specified finish for new work. The Contractor shall clean existing surfaces of dirt, grease, loose paint, etc., before refinishing.

K. The Contractor shall cut out embedded anchorage and attachment items as required to properly provide for patching and repair of the respective finishes.

L. The Contractor shall confine cutting of existing roof areas designated to remain to the limits required for the proper installation of the new work. The Contractor shall cut and remove insulation, etc., and provide temporary weather tight protection as required until new roofing and flashings are installed.

M. The Contractor shall remove temporary work, such as enclosures, signs, guards, and the like when such temporary work is no longer required or when directed at the completion of the work.

3.04 MAINTENANCE

A. The Contractor shall maintain the buildings, structures and public properties free from accumulations of waste, debris and rubbish, caused by the demolition and removal operations.

B. The Contractor shall provide on-site dump containers for collection of waste materials, debris and rubbish, and he shall wet down dry materials to lay down and prevent blowing dust.

C. At reasonable intervals during the progress of the demolition and removal work or as directed by the Engineer, the Contractor shall clean the site and properties, and dispose of waste materials, debris and rubbish.

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SECTION 01550

SITE ACCESS AND STORAGE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Access Roads

1. The General Contractor shall construct and maintain such temporary access roads as required to perform the work of this Contract.

2. Access roads, where possible, shall be located over the areas of the future road system.

3. Access roads shall be located within the property lines of the Owner unless the Contractor independently secures easements for his use and convenience. Contractor shall submit written documentation to the Engineer for any Contractor secured easements across privately held property. Easement agreement shall specify terms and conditions of use and provisions for site restoration. A written release from the property owner certifying that all terms of the easement agreement have been complied by the Contractor shall be furnished to the Engineer prior to final payment.

4. Existing access roads used by the Contractor shall be suitably maintained by the Contractor at his expense during construction. Contractor shall not be permitted to restrict Owner access to existing facilities. Engineer may direct Contractor to perform maintenance of existing access roads when Engineer determines that such work is required to insure all weather access by the Owner.

5. The Contractor shall obtain and pay all cost associated with any bonds required by the S.C. Department of Transportation for the use of State maintained roads.

B. Parking Areas

1. Each Contractor shall construct and maintain suitable parking areas for his construction personnel on the project site where approved by the Engineer and the Owner.

C. Restoration

1. At the completion of the work, the surfaces of land used for access roads and parking areas shall be restored by each Contractor to its original condition and to the satisfaction of the Engineer. At a minimum, such restoration shall include establishment of a permanent ground cover adequate to restrain erosion for all disturbed areas.

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D. Traffic Regulations

1. Contractor shall obey all traffic laws and comply with all the requirements, rules and regulations of the SCDOTand other local authorities having jurisdiction to maintain adequate warning signs, lights, barriers, etc., for the protection of traffic on public roadways.

E. Storage of Equipment and Materials

1. Contractor shall store his equipment and materials at the job site in accordance with the requirements of the General Conditions, the Supplemental Conditions, and as hereinafter specified. All equipment and materials shall be stored in accordance with manufacturer's recommendations and as directed by the Owner or Engineer, and in conformity to applicable statutes, ordinances, regulations and rulings of the public authority having jurisdiction. Where space or strip heaters are provided within the enclosure for motors, valve operators, motor starters, panels, instruments, or other electrical equipment, the Contractor shall make connections to these heaters from an appropriate power source and operate the heaters with temperature control as necessary until the equipment is installed and being operated according to its intended use.

2. Contractor shall enforce the instructions of Owner and Engineer regarding the posting of regulatory signs for loadings on structures, fire safety, and smoking areas.

3. Contractor shall not store materials or encroach upon private property without the written consent of the owners of such private property.

4. Contractor shall not store unnecessary materials or equipment on the job site, and shall take care to prevent any structure from being loaded with a weight which will endanger its security or the safety of persons.

5. Materials shall not be placed within ten (10) feet of fire hydrants. Gutters, drainage channels and inlets shall be kept unobstructed at all times.

6. Contractor shall provide adequate temporary storage buildings/facilities, if required, to protect materials or equipment on the job site.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01560

TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Dust Control

1. Contractor shall take all necessary measures to control dust from his operations, and to prevent spillage of excavated materials on public roads.

2. Contractor shall remove all spillage of excavated materials, debris or dust from public roads by methods approved by the Engineer.

3. Contractor shall sprinkle water at locations and in such quantities and at such frequencies as may be required by the Engineer to control dust and prevent it from becoming a nuisance to the surrounding area.

4. Dust control and cleaning measures shall be provided at no additional cost to the Owner.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 01600

MATERIALS AND EQUIPMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish and Install

1. Where the words "furnish", "provide", "supply", "replace", or "install" are used, whether singularly or in combination, they shall mean to furnish and install, unless specifically stated otherwise.

2. In the interest of brevity, the explicit direction "to furnish and install" has sometimes been omitted in specifying materials and/or equipment herein. Unless specifically noted otherwise, it shall be understood that all equipment and/or materials specified or shown on the Drawings shall be furnished and installed under the Contract as designated on the Drawings.

B. Concrete Foundations for Equipment

1. Each Contractor shall provide all concrete foundations shown, specified or required for all equipment furnished under their respective Contract.

2. Anchor bolts and templates for equipment foundations shall be furnished under the respective Contracts for installation by the respective Contractor. The General Contractor shall cooperate with the respective Contractors to secure a satisfactory installation and to maintain the schedule of construction.

3. All concrete foundations for equipment shall be treated, by the respective Contractor, with an approved sealer to prevent oil from seeping into the concrete.

1.02 EQUIPMENT AND MATERIALS

A. All equipment, materials, instruments or devices incorporated in this project shall be new and unused, unless indicated otherwise in the Contract Documents. Equipment and materials to be incorporated into the work shall be delivered sufficiently in advance of their installation and use to prevent delay in the execution of the work, and they shall be delivered as nearly as feasible in the order required for executing the work.

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B. The Contractor shall protect all equipment and materials from deterioration and damage, including provisions for temporary storage buildings as needed and as specified in Section 01550, Site Access and Storage. Storage of equipment and materials shall be in locations completely protected from flooding, standing water, excessive dust, falling rock, brush fire, etc. Storage areas shall be located sufficiently distant from all construction activities and the movement of construction vehicles to minimize the potential for accidental damage. Any equipment or materials of whatever kind which may have become damaged or deteriorated from any cause shall be removed and replaced by good and satisfactory items at the Contractor's expense for both labor and materials.

1.03 INSTALLATION OF EQUIPMENT

A. Equipment and materials shall be installed in accordance with the requirements of the General Conditions, Supplemental Conditions and the respective Specification Sections.

B. Concrete foundations for equipment shall be of approved design and shall be adequate in size, suitable for the equipment erected thereon, properly reinforced, and tied into floor slabs by means of reinforcing bars or dowels. Foundation bolts of ample size and strength shall be provided and properly positioned by means of suitable templates and secured during placement of concrete. Foundations shall be built and bolts installed in accordance with the manufacturer's certified drawings.

C. Before mounting equipment on a foundation, the Contractor shall clean the top surface; if necessary, rough it with a star chisel and clean again; and clean out all foundation bolt sleeves. The Contractor shall provide a sufficient number of steel plate shims about 2-inches wide and 4-inches long, and of a varying thickness from 1/8 to 1/2-inch. A combination of these shims shall be placed next to each foundation bolt to bring the bottom of the bedplate or frame about 1/8-inch above the final setting. The equipment shall be lowered by changing the combination of shims. Using brass shim stock of various thicknesses, continue to level the equipment a little at a time and in rotation until it is at the correct elevation in both directions. When the equipment is level, tighten down on the foundation bolts a little at a time in rotation to make certain the equipment remains level and does not shift on the shims. A preliminary alignment check shall be made before grout is placed.

D. Equipment shall be set, aligned and assembled in conformance with manufacturer's drawings or instructions. Run out tolerances by dial indicator method of alignment shall be plus or minus .002-inches, unless otherwise approved by the Engineer.

E. All blocking and wedging required for the proper support and leveling of equipment during installation shall be furnished by the Contractor. All temporary supports shall be removed, except steel wedges and shims, which may be left in place with the approval of the Engineer.

F. Each piece of equipment or supporting base, bearing on concrete foundations, shall be bedded in grout. The Contractor shall provide a minimum of 1-1/2-inch thick grouting under the entire baseplate supporting each pump, motor drive unit and other equipment. Grout shall be non-shrink grout, as specified under Section 03600, Grout.

G. When motors are shipped separately from driven equipment, the motors shall be received, stored, meggered once a month, and the reports submitted to the Engineer. After driven equipment is set, the motors shall be set, mounted, shimmed, millrighted, coupled and connected complete.

1.04 CONNECTIONS TO EQUIPMENT

A. Connections to equipment shall follow manufacturer's recommendations as to size and arrangement of connections and/or as shown in detail on the Drawings or approved Shop Drawings. Piping connections shall be made to permit ready disconnection of equipment with minimum disturbance of adjoining piping and equipment.

B. The Electrical Contractor or General Contractor if no electrical contract exists shall be responsible for bringing proper electrical service to each item of equipment requiring electrical service as shown on the Drawings or approved Shop Drawings. Electrical connections to equipment requiring electrical service shall be made by the Electrical Contractor, unless otherwise indicated on the Drawings or in the Technical Specifications.

C. The HVAC Contractor or General Contractor if no HVAC Contract exists shall bring and connect HVAC service to all equipment items requiring same as shown on the Drawings. Electrical connections to equipment requiring electrical service shall be made by the Electrical Contractor, unless otherwise indicated on the Drawings or in the Technical Specifications.

D. The Plumbing Contractor or General Contractor if no plumbing contract exists shall bring and connect plumbing service to all equipment items requiring same as shown on the Drawings.

1.05 SUBSTITUTIONS

A. Requests for substitutions of equipment or materials shall conform to the requirements of the General Conditions, Supplemental Conditions, and as hereinafter specified.

1. Contractor shall submit for each proposed substitution sufficient details, complete descriptive literature and performance data together with samples of the materials, where feasible, to enable the Owner and Engineer to determine if the proposed substitution is equal.

2. Contractor shall submit certified tests, where applicable, by an independent laboratory attesting that the proposed substitution is equal.

3. A list of installations where the proposed substitution is equal.

4. Requests for substitutions shall include full information concerning differences in cost, and any savings in cost resulting from such substitutions shall be passed on to the Owner.

B. Where the approval of a substitution requires revision or redesign of any part of the work, including that of other Contracts, all such revision and redesign, and all new drawings and details therefore, shall be provided by the Contractor at his own cost and expense, and shall be subject to the approval of the Owner and Engineer.

C. In the event that the Engineer is required to provide additional engineering services, then the Engineer's charges for such additional services shall be charged to the Contractor by the Owner in accordance with the requirements of the General Conditions, and the Supplemental Conditions.

D. In all cases the Owner and Engineer shall be the judge as to whether a proposed substitution is to be approved. The Contractor shall abide by their decision when proposed substitute items are judged to be unacceptable and shall in such instances furnish the item specified or indicated. No substitute items shall be used in the work without written approval of the Owner and Engineer.

E. Contractor shall have and make no claim for an extension of time or for damages by reason of the time taken by the Engineer in considering a substitution proposed by the Contractor or by reason of the failure of the Engineer to approve a substitution proposed by the Contractor.

F. Acceptance of any proposed substitution shall in no way release the Contractor from any of the provisions of the Contract Documents.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01700

PROJECT CLOSEOUT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Final Cleaning

1. At the completion of the work, the Contractor shall remove all rubbish from and about the site of the work, and all temporary structures, construction signs, tools, scaffolding, materials, supplies and equipment which he or any of his Subcontractors may have used in the performance of the work. Contractor shall broom clean paved surfaces and rake clean other surfaces of grounds.

2. Contractor shall thoroughly clean all materials, equipment and structures; all marred surfaces shall be touched up to match adjacent surfaces; dirty filters and burned out lights replaced as required; all glass surfaces cleaned and floors cleaned and polished so as to leave work in a clean and new appearing condition.

3. Contractor shall maintain cleaning until project is complete.

B. Lubrication Survey

1. A lubrication survey, made by a lubricant supply firm, subject to the approval of the Owner shall be provided and paid for by the Contractor.

2. The lubrication survey shall list all equipment, the equipment manufacturer's lubrication recommendations, and an interchangeable lubricants tabulation standardizing and consolidating lubricants whenever possible.

3. The Contractor shall supply all lubricants, applicators and labor for lubricating the equipment, in accordance with manufacturer's recommendations, for field testing and prior to final acceptance. A supply of required lubricants sufficient for start-up and one year of operation shall also be supplied by the Contractor.

4. Ten (10) copies of the approved lubrication survey shall be furnished to the Engineer prior to final acceptance.

C. Spare Parts and Special Tools

1. As soon as practicable after approval of the list of equipment, the Contractor shall furnish spare parts data for each different item of equipment listed. The data shall include a complete list of parts and supplies, with current unit prices and source or sources of supply.

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2. Contractor shall also furnish a list of parts, and supplies that are either normally furnished at no extra cost with the purchase of the equipment or specified to be furnished as part of the Contract and a list of additional items recommended by the manufacturer to assure efficient operation for a period of one-hundred and twenty (120) days for the particular installation.

3. All parts shall be securely boxed and tagged, and clearly marked on the box and individually for identification as to the name of manufacturer or supplier, applicable equipment, part number, description and location in the equipment. All parts shall be protected and packaged for a shelf life of at least ten (10) years.

4. Contractor shall furnish at no additional cost to the Owner with each piece of equipment as a minimum, one (1) complete set, or the number of sets called for in the Technical Specifications, of suitably marked special tools and appliances which may be needed to adjust, operate, maintain, or repair the equipment.

5. Contractor shall submit, for approval by the Engineer, a complete list of the special tools and appliances to be furnished. Such tools and appliances shall be furnished in approved painted steel cases properly labeled and equipped with good grade cylinder locks and duplicate keys.

D. Equipment Start-Up Services

1. Equipment start-up period, for the training of plant personnel, shall begin after satisfactory completion and acceptance of the field tests and coincidentally with the certified date of substantial completion for the part of the work for which the equipment is included. If the equipment is not covered by a certificate of substantial completion for a part of the work, the period shall begin upon substantial completion of the project.

2. During the equipment start-up period the Contractor shall furnish, at no additional cost to the Owner the services of factory trained representatives of the equipment manufacturers for the equipment designated in the Specifications to:

   a. Assist in the start-up and operations of the equipment.

   b. Assist in the training of plant personnel, designated by the Owner in the proper operation and maintenance of the equipment.

3 The Owner shall:

   a. Provide the necessary plant personnel to be instructed in the operation and maintenance of the equipment. The Owner's personnel shall operate all equipment.

   b. Pay for all fuel, power and chemicals consumed beyond quantities specified in the Contract Documents. The Contractor shall pay for fuel, power, and chemicals consumed up to the date of "certified substantial completion" except as otherwise specified herein.

4. Contractor shall be available to promptly repair all work during the start-up period so as to cause minimum disruption to the total plant operation.

5. Upon completion of a minimum of ten (10) consecutive and continuous days of satisfactory operation, or the number of days called for in the Technical Specifications, the Owner will assume operation and operating cost of the equipment. If the equipment malfunctions during this start-up period, the start-up period will be repeated until satisfactory operation is achieved.

6. In the event a system, equipment or component proves defective or is unable to meet specified performance criteria, the Contractor shall replace the defective item and the minimum one (1) year guarantee period, or the guarantee period called for in the Technical Specifications for the item shall start after satisfactory replacement and testing of the item.

E. Final Cleanup; Site Rehabilitation

1. Before finally leaving the site, the Contractor shall wash and clean all exposed surfaces which have become soiled or marked, and shall remove from the site of work all accumulated debris and surplus materials of any kind which result from his operation, including construction equipment, tools, sheds, sanitary enclosures, etc. The Contractor shall leave all equipment, fixtures, and work, which he has installed, in a clean condition. The completed project shall be turned over to the Owner in a neat and orderly condition.

2. The site of the work shall be rehabilitated or developed in accordance with other sections of the Specifications and the Drawings. In the absence of any portion of these requirements, the Contractor shall completely rehabilitate the site to a condition and appearance equal or superior to that which existed just prior to construction, except for those items whose permanent removal or relocation was required in the Contract Documents or ordered by the Owner.

F. Final Inspection

1. Final cleaning and repairing shall be so arranged as to be finished upon completion of the construction work. The Contractor will make his final cleaning and repairing, and any portion of the work finally inspected and accepted by the Engineer shall be kept clean by the Contractor, until the final acceptance of the entire work.

2. When the Contractor has finally cleaned and repaired the whole or any portion of the work, he shall notify the Engineer that he is ready for final inspection of the whole or a portion of the work, and the Engineer will thereupon inspect the work. If the work is not found satisfactory, the Engineer will order further cleaning, repairs, or replacement.

3. When such further cleaning or repairing is completed, the Engineer, upon further notice, will again inspect the work. The "Final Payment" will not be processed until the Contractor has complied with the requirements set forth, and the Engineer has made his final inspection of the entire work and is satisfied that the entire work is properly and satisfactorily constructed in accordance with the requirements of the Contract Documents.

G. Project Close Out

1. As construction of the project enters the final stages of completion, the Contractor shall, in concert with accomplishing the requirements set forth in the Contract Documents, attend to or have already completed the following items as they apply to his contract:

   a. Scheduling equipment manufacturers' visits to site.

   b. Required testing of project components.

   c. Scheduling start-up and initial operation.

   d. Scheduling and furnishing skilled personnel during initial operation.

   e. Correcting or replacing defective work, including completion of items previously overlooked or work which remains incomplete, all as evidenced by the Engineer's "Punch" Lists.

   f. Attend to any other items listed herein or brought to the Contractor's attention by the Engineer.

2. Just before the Engineer's Certificate of Substantial Completion is issued, the Contractor shall accomplish the cleaning and final adjustment of the various building components as specified in the Specifications and as follows:

   a. Clean all glass and adjust all windows and doors for proper operation.

   b. Clean all finish hardware after adjustment for proper operation.

   c. Touch up marks or defects in painted surfaces and touch up any similar defects in factory finished surfaces.

   d. Wax all resilient flooring materials.

   e. Remove bitumen from gravel stops, fascias, and other exposed surfaces.

   f. Remove all stains, marks, fingerprints, soil, spots, and blemishes from all finished surfaces, tile, stone, brick, and similar surfaces.

3. In addition, and before the Certificate of Substantial Completion is issued, the Contractor shall submit to the Engineer (or to the Owner if indicated) certain records, certifications, etc., which are specified elsewhere in the Contract Documents. A partial list of such items appears below, but it shall be the Contractor's responsibility to submit any other items which are required in the Contract Documents:

a. Test results of project components.

b. Performance Affidavits for equipment.

c. Certification of equipment or materials in compliance with Contract Documents.

d. Operation and maintenance instructions or manuals for equipment.

e. One set of neatly marked-up record drawings showing as-built changes and additions to the work under his Contract.

f. Any special guarantees or bonds (Submit to Owner).

g. Licensed surveyor's report showing elevations of weirs specified in the Contract Drawings and the final surveyed elevation.

4. The Contractor's attention is directed to the fact that required certifications and information under Item 3 above, must be submitted earlier in accordance with other Sections of the Specifications.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 02050

DEMOLITION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials and equipment in accordance with the requirements of Section 01520 - Maintenance of Utility Operations During Construction and Section 01540 - Demolition and Removal of Existing Structures and Equipment.

B. In addition, the Contractor shall demolish and remove all concrete and asphaltic paving, curbs, sidewalk, and miscellaneous yard structures as required and shown on the Contract Drawings during the construction work.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01090 - Reference Standards

B. Section 01520 - Maintenance of Utility Operations During Construction

C. Section 01540 - Demolition and Removal of Existing Structures and Equipment

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. References shall be in accordance with reference standards, codes, and specifications as set forth herein and in Section 02100 - Clearing, Grubbing, and Site Preparation.

PART 2 -- EXECUTION

2.01 DEMOLITION

A. Existing concrete and asphaltic paving, curbs, sidewalk and miscellaneous yard structures within the areas designated for new construction work shall be completely demolished and all debris removed from the site.

B. Excavation caused by demolition shall be backfilled with fill free from rubbish and debris.

C. Work shall be performed in such manner as not to endanger the safety of the workmen or the public or cause damage to nearby structures.

D. Provide all barriers and precautionary measures in accordance with Owner's requirements and other authorities having jurisdiction.

E. Where parts of existing structures are to remain in service, demolish the portions to be removed, repair damage, and leave the structure in proper condition for the intended use. Remove concrete and masonry to the lines designated by drilling, chipping, or other suitable methods. Leave the resulting surfaces reasonably true and even, with sharp straight corners that will result in neat joints with new construction and be satisfactory for the purpose intended. Where existing reinforcing rods are to extend into new construction, remove the concrete so that the reinforcing is clean and undamaged. Cut off other reinforcing 1/2-inch below the surface and fill with epoxy resin binder flush with the surface.

F. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of the adjoining and/or nearby structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

2.02 DISPOSAL OF MATERIAL

A. All debris resulting from the demolition and removal work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed. All other material shall be disposed of off site by the Contractor at his expense.

B. Burning of any debris resulting from the demolition will not be permitted at the site.

- END OF SECTION -

SECTION 02100

CLEARING, GRUBBING, AND SITE PREPARATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Includes all labor, material, equipment and appliances required for the complete execution of any additions, modifications, or alterations to existing building(s) and new construction work as shown on the Drawings and specified herein.

B. Principal items of work include:

1. Notifying all authorities owning utility lines running to or on the property. Protecting and maintaining all utility lines to remain and capping those that are not required in accordance with instructions of the Utility Companies, and all other authorities having jurisdiction.

2. Clearing the site within the Contract Limit Lines, including removal of grass, brush, shrubs, trees, loose debris and other encumbrances except for trees marked to remain.

3. Boxing and protecting all trees, shrubs, lawns and the like within areas to be preserved. Relocating trees and shrubs, so indicated on the Drawings, to designated areas.

4. Repairing all injury to trees, shrubs, and other plants caused by site preparation operations shall be repaired immediately. Work shall be done by qualified personnel in accordance with standard horticultural practice and as approved by the Engineer.

5. Removing topsoil to its full depth from designated areas and stockpiling on site where directed by the Engineer for future use.

6. Disposing from the site all debris resulting from work under this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02200 – Earthwork

B. Section 02276 – Erosion and Sedimentation Control

1.03 STREET AND ROAD BLOCKAGE

A. Closing of streets and roads during progress of the work shall be in compliance with the requirements of the Owner and other authorities having jurisdiction. Access shall be provided to all facilities remaining in operation.

1.04 PROTECTION OF PERSONS AND PROPERTY

A. All work shall be performed in such a manner to protect all personnel, workmen, pedestrians and adjacent property and structures from possible injury and damage.

B. All conduits, wires, cables and appurtenances above or below ground shall be protected from damage.

C. Provide warning and barrier fence where shown on the Drawings and as specified herein.

PART 2 -- EXECUTION

2.01 CLEARING OF SITE

A. Before removal of topsoil, and start of excavation and grading operations, the areas within the clearing limits shall be cleared of debris.

2.02 STRIPPING AND STOCKPILING EXISTING TOPSOIL

A. Existing topsoil and sod on the site within areas designated on the Drawings shall be stripped to whatever depth it may occur and stored in locations directed by the Engineer.

B. The topsoil shall be free of stones, roots, brush, rubbish, or other unsuitable materials before stockpiling the topsoil.

C. Care shall be taken not to contaminate the stockpiled topsoil with any unsuitable materials.

2.03 GRUBBING

A. Grubbing shall consist of the removal and disposal of all stumps, roots, logs, sticks and other perishable materials to a depth of at least 6-inches below ground surfaces.

2.04 DISPOSAL OF MATERIAL

A. All debris resulting from the clearing and grubbing work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed by the Engineer for reuse in this Project or removal by others.

B. Burning of any debris resulting from the clearing and grubbing work will not be permitted at the site.

2.05 WARNING AND BARRIER FENCE

A. The fence shall be made of a visible, lightweight, flexible, high strength polyethylene material. The fence shall be MIRASAFE as manufactured by Mirafi, Inc., or equal.

B. Physical Properties

Fence:

Color:	International Orange
Roll Size:	4' x 164'
Roll weight:	34 lbs.
Mesh opening:	1-1/2" x 3"

Posts:

ASTM Designation:	ASTM 702
Length:	5 feet long (T-Type)
Weight:	1.25 #/Foot (min)
Area of Anchor Plate:	14 Sq. In.

C. Drive posts 12 to 18 inches into ground every 10' to 12'. Wrap fence material around first terminal post allowing overlap of one material opening. Use metal tie wire or plastic tie wrap to fasten material to itself at top, middle and bottom. At final post, cut with utility knife or scissors at a point halfway across an opening. Wrap around and tie at final post in the same way as the first post.

D. Use tie wire or tie wrap at intermediate posts and splices as well. Thread ties around a vertical member of the fence material and the post and bind tightly against the post. For the most secure fastening, tie at top, middle and bottom. Overlap splices a minimum of four fence openings, tie as above, fastening both edges of the fence material splice overlap.

- END OF SECTION -

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SECTION 02140

DEWATERING

PART 1 -- GENERAL

1.01 WORK INCLUDED

A. Furnish all labor, materials, and equipment, perform all work necessary to lower and control the groundwater levels and hydrostatic pressures to permit the safe draining of all structures (including aeration basins and junction structure) and excavations and for construction to be performed in dry conditions. The work shall include the following:

1. Testing, operation, maintenance, supervision, rewatering, and final dismantling and removal from the site of the dewatering system.

2. The cost of any replacement or rehabilitation of the subgrade or structures damaged due to dewatering system failures or Contractor negligence.

3. Compliance with all regulations relating to this work.

4. The diversion, collection, and removal of all ice, snow and surface runoff from the work areas, and removal of groundwater from new excavations to permit construction in the dry.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

1.03 REFERENCE SPECIFICATIONS CODES AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents to the extent that the provisions therein are not in conflict with the requirements of this Section.

1.	ASTM D1556	Density of soil in place by the Sand Cone Method.
2.	ASTM D2167	Density of soil in place by the Rubber Balloon Method.
3.	Bureau of Reclamation	Groundwater Manual Sediment Test by Imhoff Cone

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals:

1. Name of dewatering subcontractor, if applicable

2. Shop Drawings indicating the following:

a. Plans showing the methods and location of dewatering and discharge including a sufficient number of detailed sections to clearly illustrate the scope of work.

b. Relationship of the dewatering system, observation wells, and discharge line to existing buildings, other structures, utilities, streets and new construction.

c. Utility locations.

d. Drawings shall bear the seal and signature of the qualified Registered Professional Engineer currently registered in the State of South Carolina in charge of preparing the drawings.

e. List of materials and equipment to be used.

f. A sample of all well record forms to be maintained during construction.

3. Detailed description of the sequence of dewatering operations

4. Dewatering well installation records indicating an identification number, location, dimensions, and installation procedures and materials.

5. Observation well installation records indicating an identification number, location, dimensions, and installation procedures and materials.

6. Emergency observation plan to be put into operation during failure of the dewatering system

7. Monthly Dewatering System Monitoring Reports containing the following data on approved forms:

   a. For observation wells, daily piezometric levels shall be identified by date, time, well number and system (subsystem if multiple pumps are used) pumping rate. Piezometric levels shall be noted in feet of drawdown and groundwater elevation.

   b. For dewatering wells, suspended material test results shall be identified by date, time, well number, well pumping rate (if monitored) and system (subsystem if multiple pumps are used) pumping rate.

   c. Installation records for new wells.

8. Schedule and records of all maintenance tests for primary and standby dewatering systems including the following:

   a. Maintenance tests and water quality tests for suspended matter at the discharge point including date, time of day, elapsed times of tests procedures, components tested, suspended particles, resultant observations and well readings.

b. Daily discharge rates.

c. Installation and removal of wells.

d. General observations of the system such as equipment running times, and failures.

9. Dewatering well removal records

10. Observation well removal records

1.05 QUALITY ASSURANCE

A. The Contractor shall be solely responsible for the arrangement, location, and depths of the dewatering system necessary to accomplish the work described herein.

B. Dewatering shall prevent the loss of fines, seepage, boils, quick conditions or softening of the foundation strata while maintaining stability of the sides and bottom of the excavation, and providing dry conditions for construction operations.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Materials, especially the well screen, shall be carefully chosen to be compatible with the environment to prevent erosion, deteriorization, and clogging.

B. Surging of the natural formation to form a "gravel pack" is strictly prohibited.

PART 3 -- EXECUTION

3.01 EXAMINATION OF THE SITE

A. Become familiar with the surface and subsurface site conditions.

B. Obtain the data required to analyze the water and soil environment at the site in order to assure that the materials used for the dewatering systems will not erode, deteriorate, clog or otherwise hinder the system's performance during the period of the dewatering.

C. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of adjoining structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

3.02 DESIGN

A. The dewatering system shall be capable of relieving all hydrostatic pressure against the height of the excavation walls and of lowering the hydrostatic level below the bottom of the base slab a minimum of four (4) feet in the work areas both prior to excavation, and during excavation and construction.

B. The dewatering system shall be segmented so that if the operation of any one segment is disrupted, the remaining segment plus activated redundant components are capable of maintaining the groundwater at the stated levels.

C. Provide, operate and maintain all ditches, berms, site grading, sumps and pumping facilities to divert, collect and remove all surface water from work areas. All collected water shall be discharged into the outfall pipe.

D. Provide pipe and pumps of sufficient size and quantity to be able to flood the excavation within 12 hours in an emergency situation. Restoration of the working area shall be carried out by the Contractor at no additional cost to the Owner.

E. Carry the dewatering system discharge through pipes out of the area of the excavation into the outfall junction manhole shown on the Drawings. Provide meters to measure the discharge flow.

F. Place a portion of the header and discharge system underground to provide vehicle crossings or access to existing structure as required.

G. Provide a standby dewatering system that meets the following requirements:

1. Provide 100 percent standby power.

2. Provide a 15 percent minimum increase in the number of wells and related equipment required to operate the dewatering system installed and ready to operate.

3. Provide a minimum of three separate power units for the standby power system and one installed auxiliary unit for each individually powered pump.

4. Provide separate discharge lines from each well or common lines with valves such that any well or wells that malfunction or are damaged can be isolated form the others.

5. The systems shall be laid out and designed in such a way that portions of the system may be isolated for routine maintenance or repair in case of accidental damage without affecting the normal operation of the system.

H. Provide sufficient fuel to maintain a five day supply on site for fuel power systems.

I. Provide observation wells to determine compliance with dewatering requirements as indicated on the Drawings, Shop Drawings, and the Engineer.

J. Designate certain observation wells as emergency observation wells.

3.03 INSPECTION

A. All tests and inspections require the witnessing and written approval of the Owner and Engineer.

B. Provide safe access for the owner and Engineer to perform testing and inspection.

C. The Owner and Engineer will provide oral and written notice to the Contractor for all tests and inspections that do not meet approval.

3.04 INSTALLATION AND TESTING

A. Install the dewatering system from the existing ground surface or from the bottom of an excavation which is located above the natural groundwater level.

B. Pump each well individually at its maximum or design flow and take a water sample using the following procedures:

1. Obtain samples from stopcocks located along the discharge lines at points of high turbulence or between 4 and 8 o'clock on the perimeter of straight sections of pipe.

2. Flush the stopcock for a few seconds before taking a sample.

3. Take a 1 liter sample with the stopcock fully open.

C. Test the sample following the Sediment Test by Imhoff Cone for two to three minutes and measure the volume of settled materials to the nearest 0.01 milliliters (0.01 milliliters = 10 ppm).

D. All wells shall be evaluated as follows:

1. Wells producing 10 ppm or less shall be accepted.

2. Wells producing between 10 and 20 ppm may be accepted by the Engineer based on the evaluation of average ppm for all wells, ppm of adjacent wells, and total quantity of water which is actually pumped to dewater the excavation.

3. Well producing more than 20 ppm shall be abandoned and backfilled.

E. Observation wells shall consist of a standpipe or riser of minimum 1.0-inch inside diameter and a minimum three (3) foot long well-point screen or slotted PVC section at the bottom. Observation wells shall be installed as follows:

1. Employ the jetting method for all observation wells except those within ten feet of existing structures, piping or utilities.

2. Employ Case Boring Techniques for all observation wells within ten feet of existing structures, piping, or utilities and backfill the annulus between the well point or riser and the natural soil with a free flowing granular material similar to Ottawa Sand.

F. Test observation wells by adding or removing water from the riser to demonstrate their proper functioning.

3.05 DEWATERING PROCEDURE

A. Following excavation support system installation and dewatering system installation and testing and prior to excavation, place the dewatering system into operation and lower the water level.

B. Schedule the dewatering work to coordinate with all the other related work such as excavation, excavation support installation, placement of concrete walls and slabs, and any other operations by other Contractors that might be affected by this work.

C. Test the standby dewatering system with the following procedures:

1. Shut off the primary power source and demonstrate that the standby power can be activated prior to the groundwater level rising to within one (1) foot of the bottom of base slab elevation and that the standby power source is adequate to draw the groundwater level back down to the Contractor's design depth or to the minimum required depths.

2. Shut off one segment of the system and show that redundant components can be activated prior to the groundwater level rising to within one (1) foot of the bottom of base slab elevation and that the system is adequate to draw the groundwater level back down to the Contractor's design depth or to the minimum required depths.

3. If the dewatering system fails to meet either performance requirement, the Contractor shall draw the groundwater level to a greater depth, add wells, or modify the system such that it will be in conformance with these requirements when retested.

D. Operate the dewatering system continuously twenty-four (24) hours per day, seven (7) days per week until all structures have been satisfactorily constructed, including placement of fill materials, and no longer require dewatering.

3.06 MONITORING

A. Measure the piezometric water levels to the nearest one-tenth foot in all observation wells and submit the readings daily.

B. Measure the concentration of suspended material in the discharge water of each well once every two days. Wells which exceed the acceptable level of solids concentration shall be replaced.

C. Test the performance of the standby system and all components by demonstrating that the system is operational at least every two weeks.

D. Test the observation wells every two weeks by adding and removing water from the risers to demonstrate their proper functioning.

E. Observation wells that become inoperable shall be immediately replaced while construction is halted if the Engineer determines that the observation well is critical.

F. Remove and add riser pipe of each observation well located within the excavation as construction progresses until the well conflicts with the structure. When the conflict occurs, abandon the observation well, fill it with grout, and cut the riser off at grade.

G. In the event of a dewatering system failure, take the following steps:

1. Conduct in situ density tests conforming to ASTM D1556 or ASTM D2167 immediately above and at the structure founding grades.

2. Remove all soils that show unacceptable density and replace them with compacted fill as indicated in Section 02200, Earthwork.

3. Test the repaired soils as required by the Owner and Engineer to verify that they have been returned to their original in situ state or better.

4. Repair or replace damaged structures.

3.07 REWATERING AND REMOVAL OF DEWATERING SYSTEM

A. Obtain written approval from the Owner and Engineer to begin rewatering operations.

B. Provide an adequate weight of fill to prevent buoyancy.

C. Pump water into the excavation such that the water level inside the excavation is always at a higher level than the rising groundwater on the outside until the groundwater level has reached its static level.

D. Remove all dewatering wells, buried and surface piping, cables, pump foundations, structural supports and all other support facilities.

E. Backfill as specified in Section 02200, Earthwork, all trenches and excavations below final grades or in fill areas.

F. Provide documentation of dewatering and observation well removal including the date of removal, well number, location, procedures, and materials used.

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SECTION 02200

EARTHWORK

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all labor, equipment and materials required to complete all work associated with excavation, including off-site borrow excavation, dewatering, backfill, drainage layers beneath and around structures, foundation and backfill stone, filter fabric, embankments, stockpiling topsoil and any excess suitable material in designated areas, in place compaction of embankments, backfill and subgrades beneath foundations and roadways, excavation support, disposing from the site all unsuitable materials, providing erosion and sedimentation control grading, site grading and preparation of pavement and structure subgrade, and other related and incidental work as required to complete the work shown on the Drawings and specified herein.

B. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Drawings or established by the Engineer.

C. It is the intent of this Specification that the Contractor conduct the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized.

D. All work under this Contract shall be done in conformance with and subject to the limitations of the latest editions of the South Carolina State Highway Department Standard Specifications for Highway Construction.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina State Highway Department Standard Specifications for Highway Construction.

2. American Society for Testing and Materials (ASTM):

ASTM C 127	Test for Specific Gravity and Absorption of Coarse Aggregate.
ASTM C 136	Test for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 422	Particle Size Analysis of Soils.
ASTM D 423	Test for Liquid Limit of Soils.
ASTM D 424	Test for Plastic Limit and Plasticity Index of Soils.
ASTM C 535	Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
ASTM D 698	Standard Method of Test for the Moisture - Density Relations of Soils Using a 5.5 lb. (2.5 kg) Rammer and a 12-inch (305 mm) Drop.
ASTM D1556	Test for Density of Soil in Place by the Sand-Cone Method.
ASTM D1557	Test for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lbs. (4.5 kg) Rammer and 18-inch (457 mm) Drop.
ASTM D2049	Test Method for Relative Density of Cohesionless Soils.
ASTM D2167	Test for Density of Soil in Place by the Rubber-Balloon Method.
ASTM D2216	Test for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures.
ASTM D2487	Test for Classification of Soils for Engineering Purposes.
ASTM D2922	Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

1.04 SUBSURFACE CONDITIONS

A. Information on subsurface conditions is referenced under Division 1, General Requirements.

B. Attention is directed to the fact that there may be water pipes, storm drains and other utilities located in the area of proposed excavation. Perform all repairs to same in the event that excavation activities disrupt service.

1.05 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 - Submittals, the Contractor shall submit the following:

1. Name and location of all material suppliers.

2. Certificate of compliance with the standards specified above for each source of each material.

3. List of disposal sites for waste and unsuitable materials and all required permits for use of those sites.

4. Samples of synthetic filter fabric with manufacturer's certificates or catalog cuts stating the mechanical and physical properties. Samples shall be at least one (1) foot wide and four (4) feet long taken across the roll with the warp direction appropriately marked.

5. Monitoring plan and pre-construction condition inspection and documentation of all adjacent structures, utilities, and roadways near proposed installation of excavation support systems and near areas where dewatering is required to facilitate construction.

1.06 PRODUCT HANDLING

A. Soil and rock material shall be excavated, transported, placed, and stored in a manner so as to prevent contamination, segregation and excessive wetting. Materials which have become contaminated or segregated will not be permitted in the performance of the work and shall be removed from the site.

1.07 USE OF EXPLOSIVES

A. Use of explosive for excavation purposes will not be permitted on site.

PART 2 -- PRODUCTS

2.01 MATERIALS AND CONSTRUCTION

A. Earthwork Materials
1. Fill Material, General
a. Approval Required: All fill material shall be subject to the approval of the OWNER.
b. Notification: For approval of imported fill material, notify the OWNER at least one week in advance of intention to import material, designate the proposed borrow area and permit the OWNER to sample as necessary from the borrow area for the purpose of making acceptance tests to prove the quality of the material.

2. On-Site Fill Material: Soil exclusive of organic matter, frozen lumps or other deleterious substances, and containing no rocks larger than 2 inches or lumps larger than 3 inches.

3. Imported Fill Materials: Meet the requirements of on-site fill material.

4. Sand Cushions and Sand Fill: Consists of a sand-gravel fill of such gradation that 100 percent will pass a 3/8-inch sieve and not more than 10 percent by weight is lost by washing.

5. Coarse Aggregate: Conform to the SCDOT SSHC 306.03 (SCDOT Aggregate No. 57) and having the following gradation:

SIEVE DESIGNATION	PERCENT BY WEIGHT PASSING
2-inch	-
1-1/2-inch	100
1-inch	95-100
1/2-inch	25-60
No. 4	0-10
No. 8	0-5

6. Drainage Aggregate: Conform to the SCDOT SSHC Section 801.02 (SCDOT Aggregate No. 789) and having the following gradation:

SIEVE DESIGNATION	PERCENT BY WEIGHT PASSING
3/4-inch	100
1/2-inch	95-100
3/8-inch	80-100
No. 4	20-50
No. 16	0-6
No. 100	0-2

7. Fine Aggregate: Conform to the SCDOT SSHC 306.04 and having the following gradation:

SIEVE DESIGNATION	PERCENT BY WEIGHT PASSING
No. 4	100
No. 16	25-75
No. 100	0-25

8. Pea Gravel: Clean, naturally rounded aggregate, 1/8 to 3/4-inch in diameter per ASTM C 33.
9. Topsoil: Dark organic weed free loam; free of muck, roots, rocks larger than 1/2 inch, subsoil, and foreign matter.

2.02 SELECT FILL

A. Soils from the excavations meeting requirements stipulated herein with the exceptions of topsoil and organic material may be used as select fill for backfilling, constructing embankments, reconstructing existing embankments, and as structural subgrade support. Sample existing soil conditions before bidding to confirm if excavations will require select fill.

B. Select fill used for embankment construction shall be a silty or clayey soil material with a Maximum Liquid Limit (LL) of 50 and a Plasticity Index (PI) between 7 and 20.

C. Select fill used for backfilling shall either be material as described in Paragraph B above or a granular soil material with a Maximum Plasticity Index (PI) of 6.

D. Regardless of material used as select fill, materials shall be compacted at a moisture content satisfactory to the Engineer, which shall be approximately that required to produce the maximum density except that the moisture content shall not be more than 2% below nor more than 2% above the optimum moisture content for the particular material tested in accordance with the ASTM D698.

E. Select fill used as subgrade support shall be a coarse aggregate material meeting the gradation requirements of #57 or #78 aggregates in accordance with ASTM C-33, or Aggregate Base Course (ABC) as defined in Section 02207 – Aggregate Materials.

F. Where excavated material does not meet requirements for select fill, Contractor shall furnish off-site borrow material meeting the specified requirements herein. Determination of whether the borrow material will be paid for as an extra cost will be made based on Article 4 of the General Conditions, as amended by the Supplementary Conditions. When the excavated material from required excavations is suitable for use as backfill, bedding, or embankments, but is replaced with off-site borrow material for the Contractor's convenience, the costs associated with such work and material shall be borne by the Contractor.

2.03 TOPSOIL

A. Topsoil shall be considered the surface layer of soil and sod, suitable for use in seeding and planting. It shall contain no mixture of refuse or any material toxic to plant growth.

2.04 GEOTEXTILES

A. The Contractor shall provide geotextiles as indicated on the Drawings and specified herein. The materials and placement shall be as indicated under Section 02274 - Geotextiles.

PART 3 -- EXECUTION

3.01 SAFETY

A. Comply with local regulations and with the provisions of the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc., Occupational Safety and Health Act and all other applicable safety regulations.

3.02 STRIPPING OF TOPSOIL

A. In all areas to be excavated, filled, paved, or graveled the topsoil shall be stripped to its full depth and shall be deposited in storage piles on the site, at locations designated by the Engineer, for subsequent reuse. Topsoil shall be kept separated from other excavated materials and shall be piled free of roots and other undesirable materials.

3.03 EXCAVATION

A. All material excavated, regardless of its nature or composition, shall be classified as UNCLASSIFIED EXCAVATION. Excavation shall include the removal of all soil, rock, weathered rock, rocks of all types, boulders, conduits, pipe, and all other obstacles encountered and shown to be removed within the limits of excavation shown on the Drawings or specified herein. The cost of excavation shall be included in the Lump Sum Bid Price and no additional payment will be made for the removal of obstacles encountered within the excavation limits shown on the Drawings and specified herein.

B. Blasting or other use of explosives shall not be used for excavation purposes.

C. All suitable material removed in the excavation shall be used as far as practicable in the formation of embankments, subgrades, and shoulders, and at such other places as may be indicated on the Drawings or indicated by the Engineer. No excavation shall be wasted except as may be permitted by the Engineer. Refer to the drawings for specific location and placement of suitable excavated materials in the formation of embankments, backfill, and structural and roadway foundations. THE ENGINEER AND/OR MATERIALS TESTING CONSULTANT WILL DESIGNATE MATERIALS THAT ARE UNSUITABLE. The Contractor shall furnish off site disposal areas for the unsuitable material. Where suitable materials containing excessive moisture are encountered above grade in cuts, the Contractor shall construct above grade ditch drains prior to the excavation of the cut material when in the opinion of the Engineer and/or materials testing consultant such measures are necessary to provide proper construction.

D. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such excavation support, pumping and drainage as may be required. Excavation shall be made in accordance with the grades and details shown on the Drawings and as specified herein.

E. Excavation slopes shall be flat enough to avoid slides that will cause disturbance of the subgrade or damage of adjacent areas. Excavation requirements and slopes shall be as indicated in the Drawings. The Contractor shall intercept and collect surface runoff both at the top and bottom of cut slopes. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded as shown on the Drawings or as may be indicated by the Engineer. Concurrent with the excavation of cuts the Contractor shall construct intercepting berm ditches or earth berms along and on top of the cut slopes at locations shown on the Drawings or designated by the Engineer. All slopes shall be finished to reasonably uniform surfaces acceptable for seeding and mulching operations. No rock or boulders shall be left in place which protrude more than 1 foot within the typical section cut slope lines, and all rock cuts shall be cleaned of loose and overhanging material. All protruding roots and other objectionable vegetation shall be

removed from slopes. The Contractor shall be required to submit plans of open-cut excavation for review by the Engineer before approval is given to proceed.

F. It is the intent of these Specifications that all structures shall bear on an aggregate base, crushed stone or screened gravel bedding placed to the thickness shown on the Drawings, specified in these Specifications, or not less than 6-inches. Bedding for process piping shall be as specified in Section 15000 - Basic Mechanical Requirements, or as shown on the Drawings.

G. The bottom of all excavations for structures and pipes shall be examined by the Engineer and/or materials testing consultant for bearing value and the presence of unsuitable material. If, in the opinion of the Engineer and/or materials testing consultant, additional excavation is required due to the low bearing value of the subgrade material, or if the in-place soils are soft, yielding, pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted select fill, and/or crushed stone or screened gravel as indicated by the Engineer. Payment for such additional work ordered by the Engineer shall be made as an extra by a Change Order in accordance with the General Conditions and Division 1. No payment will be made for subgrade disturbance caused by inadequate dewatering or improper construction methods.

H. All cuts shall be brought to the grade and cross section shown on the Drawings, or established by the Engineer, prior to final inspection and acceptance by the Engineer.

I. Slides and overbreaks which occur due to negligence, carelessness or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as indicated by the Engineer at no additional cost to the Owner. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed.

3.04 EXCAVATION SUPPORT

A. The Contractor shall furnish, place, and maintain such excavation support which may be required to support sides of excavation or to protect pipes and structures from possible damage and to provide safe working conditions. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the expense of the Contractor. The Contractor shall be responsible for the adequacy of all supports used and for all damage resulting from failure of support system or from placing, maintaining and removing it.

B. Selection of and design of any proposed excavation support systems is exclusively the responsibility of the Contractor. Contractor shall submit drawings and calculations on proposed systems sealed by a Professional Engineer currently registered in the State of South Carolina.

C. The Contractor shall exercise caution in the installation and removal of supports to insure that excessive or unusual loadings are not transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to installation or removal of excavation support system.

D. Contractor shall monitor movement in the excavation support systems as well as movement at adjacent structures, utilities and roadways near excavation supports. Contractor shall submit a monitoring plan developed by the excavation support design engineer. All pre-construction condition assessment and documentation of adjacent structures on-site and off-site shall be performed by the Contractor. If any sign of distress such as cracking or movement occurs in any adjacent structure, utility or roadway during installation of supports, subsequent excavation, service period of supports, subsequent backfill and construction, or removal of supports, Engineer shall be notified immediately. Contractor shall be exclusively responsible for repair of any damage to any roadway, structure, utility, pipes, etc. both on-site and off-site, as a result of his operations.

E. All excavation supports shall be removed upon completion of the work except as indicated herein. The Engineer may permit supports to be left in place at the request and expense of the Contractor. The Engineer may order certain supports left permanently in place in addition to that required by the Contract. The cost of the materials so ordered left in place, less a reasonable amount for the eliminated expense of the removal work omitted, will be paid as an extra by a Change Order in accordance with the General Conditions and Division 1. Any excavation supports left in place shall be cut off at least two (2) feet below the finished ground surface or as directed by the Engineer.

3.05 PROTECTION OF SUBGRADE

A. To minimize the disturbance of bearing materials and provide a firm foundation, the Contractor shall comply with the following requirements:

1. Use of heavy rubber-tired construction equipment shall not be permitted on the final subgrade unless it can be demonstrated that drawdown of groundwater throughout the entire area of the structure is at least 3 feet below the bottom of the excavation (subgrade). Even then, the use of such equipment shall be prohibited should subgrade disturbance result from concentrated wheel loads.

2. Subgrade soils disturbed through the operations of the Contractor shall be excavated and replaced with compacted select fill or crushed stone at the Contractor's expense as indicated by the Engineer.

3. The Contractor shall provide positive protection against penetration of frost into materials below the bearing level during work in winter months. This protection can consist of a temporary blanket of straw or salt hay covered with a plastic membrane or other acceptable means.

3.06 PROOFROLLING

A. The subgrade of all structures and all areas that will support pavements or select fill shall be proofrolled. After stripping of topsoil, excavation to subgrade and prior to placement of fills, the exposed subgrade shall be carefully inspected by probing and testing as needed. Any topsoil or other organic material still in place, frozen, wet, soft, or loose soil, and other undesirable materials shall be removed. The exposed subgrade shall be proofrolled with a heavily loaded tandem-wheeled dump truck to check for pockets of soft material hidden beneath a thin crust of better soil. Any unsuitable materials thus exposed shall be removed and replaced with an approved compacted material.

3.07 DEWATERING

A. Dewatering operations shall be conducted as specified in Section 02140 Dewatering.

3.08 EMBANKMENTS

A. The Contractor shall perform the construction of embankments in such a manner that cut and fill slopes will be completed to final slopes and grade in a continuous operation. The operation of removing excavation material from any cut and the placement of embankment in any fill shall be a continuous operation to completion unless otherwise permitted by the Engineer.

B. Surfaces upon which embankments are to be constructed shall be stripped of topsoil, organic material, rubbish and other extraneous materials. After stripping and prior to placing embankment material, the Contractor shall compact the top 12-inches of in place soil as specified under Paragraph 3.09, COMPACTION.

C. Any soft or unsuitable materials revealed before or during the in place compaction shall be removed as indicated by the Engineer and/or materials testing consultant and replaced with select fill.

D. Ground surfaces on which embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the embankment with the existing surface. The embankment soils shall be as specified under Part 2 - Products, and shall be deposited and spread in successive, uniform, approximately horizontal layers not exceeding 8-inches in compacted depth for the full width of the cross section, and shall be kept approximately level by the use of effective spreading equipment. Hauling shall be distributed over the full width of the embankment, and in no case will deep ruts be allowed to form during the construction of the embankment. The embankment shall be properly drained at all times. Each layer of the embankment shall be thoroughly compacted to the density specified under Paragraph 3.09, COMPACTION.

E. The embankment or fill material in the layers shall be of the proper moisture content before rolling to obtain the prescribed compaction. Wetting or drying of the material and manipulation when necessary to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankment thus affected shall be delayed until the material has dried to the required moisture content. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken at frequent intervals. From these tests, corrections, adjustments, and modifications of methods, materials, and moisture content will be made to construct the embankment.

F. Where embankments are to be placed and compacted on hillsides, or when new embankment is to be compacted against embankments, or when embankment is built in part widths, the slopes that are steeper than 4:1 shall be loosened or plowed to a minimum depth of 6 inches or, if in the opinion of the Engineer, the nature of the ground is such that greater precautions should be taken to bind the fill to the original ground then benches shall be cut in the existing ground as indicated by Engineer.

G. When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portions of the embankments and the other material which meets the requirements for select fill shall be incorporated into the formation of the embankments. Stones or fragmentary rock larger than 4-inches in their greatest dimension will not be allowed within the top 6-inches of the final grade. Stones, fragmentary rock, or boulders larger than 12-inches in their greatest dimension will not be allowed in any portions of embankments and shall be disposed of by the Contractor as indicated by the Engineer. When rock fragments or stone are used in embankments, the material shall be brought up in layers as specified or directed and every effort shall be exerted to fill the voids with finer material to form a dense, compact mass which meets the densities specified for embankment compaction.

3.09 BACKFILLING

A. All structures and pipes shall be backfilled with the type of materials shown on the Drawings and specified herein. Select fill shall be deposited in successive, uniform, approximately horizontal layers not exceeding 8-inches in compacted depth for the full width. Stones or fragmentary rock larger than 4-inches in their greatest dimension will not be allowed within the top 6-inches of the ground nor within 6 inches of pipes. No stone or fragmentary rock larger than 12-inches in their greatest dimension will be allowed for any portion of backfill. Compaction shall be in accordance with the requirements of Paragraph 3.09, COMPACTION.

B. Where excavation support is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when supports are removed. If significant volumes of soil cannot be prevented from clinging to the extracted supports, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that supports will be installed in similar soil conditions or employ other appropriate means to prevent loss of support.

3.10 COMPACTION

A. The Contractor shall compact embankments, backfill, crushed stone, aggregate base, and in place subgrade in accordance with the requirements of this Section. The densities specified herein refer to percentages of maximum density as determined by the noted test methods. Compaction of materials on the project shall be in accordance with the following schedule:

	Density % Std. Proctor (D698)	Density % Mod. Proctor (D1557)	Max. Lift Thickness as Compacted Inches
Embankments Beneath Structures*	98	95	8
Other Embankments	95	92	8
Backfill Around Structures	95	92	8
Backfill in Pipe Trenches	95	92	8
Crushed Stone Beneath Structures	**	**	12
Select Sand	--	98	8
Aggregate Base Course (ABC) Beneath Pavements and Structures	--	98	8
Crushed Stone Backfill	**	**	12
Crushed Stone Pipe Bedding	**	**	12
In place Subgrade Beneath Structures	98	95	Top 12-inches

* Embankments beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope.

** The aggregate shall be compacted to a degree acceptable to the Engineer by use of a vibratory compactor and/or crawler tractor.

B. Field density tests will be made by the materials testing consultant to determine if the specified densities have been achieved, and these tests shall be the basis for accepting or rejecting the compaction. In-place density tests will be performed in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. The Engineer in conjunction with the materials testing consultant will be the judge as to which test method will be the most appropriate. Failure to achieve the specified densities shall require the Contractor to re-compact the material or remove it as required. The Contractor shall, if necessary, increase his compactive effort by increasing the number of passes, using heavier or more suitable compaction equipment, or by reducing the thickness of the layers. The Contractor shall adjust the moisture contents of the soils to bring them within the optimum range by drying them or adding water as required.

B. Testing will be performed as frequently as deemed necessary by the Engineer and/or materials testing consultant. As a minimum, one in-place density test shall be performed for each 1000 cubic yards of embankment placed and 500 cubic yards of backfill placed or one test performed each day for either.

3.11 REMOVAL OF EXCESS AND UNSUITABLE MATERIALS

A. The Contractor shall remove and dispose of off-site all unsuitable materials. Within thirty (30) consecutive days after Notice to Proceed, the Contractor shall submit to the Engineer for review all required permits and a list of disposal sites for the unsuitable materials. If the disposal site is located on private property, the submittal shall also include written permission from the owner of record.

B. All unsuitable materials shall be disposed of in locations and under conditions that comply with federal, state and local laws and regulations.

C. The Contractor shall obtain an off-site disposal area prior to beginning demolition or excavation operations.

D. All excess and unsuitable materials shall be hauled in trucks of sufficient capacity and tight construction to prevent spillage. Trucks shall be covered to prevent the propagation of dust.

E. When all excess and unsuitable material disposal operations are completed, the Contractor shall leave the disposal sites in a condition acceptable to the Owner and Owner(s) of the disposal site(s).

3.12 BORROW EXCAVATION

A. Description

The work covered by this section consists of the excavation of approved material from borrow sources and the hauling and utilization of such material as required on the Drawings or directed by the Engineer. It shall also include the removing, stockpiling, and replacement of topsoil on the borrow source; the satisfactory disposition of material from the borrow source which is not suitable for use; and the satisfactory restoration of the borrow source and haul roads to an acceptable condition upon completion of the work.

Borrow excavation shall not be used before all available suitable unclassified excavation has been used for backfill and incorporated into the embankments.

B. Coordination with Seeding Operations

The Contractor shall coordinate the work covered by this section with the construction of embankments so that the requirements of Section 02200 are met.

C. Materials

All material shall meet the requirements of Division 2 shown below:

Borrow Material.....Section 02200, Subsection 2.01 - Select Fill

D. Construction Methods

1. General

The surface of the borrow area shall be thoroughly cleared and grubbed and cleaned of all unsuitable material including all organics, topsoil, etc., before beginning the excavation. Disposal of material resulting from clearing and grubbing shall be in accordance with Section 02100.

Each borrow operation shall not be allowed to accumulate exposed, erodible slope area in excess of 1 acre at any one given time without the Contractor's beginning permanent seeding and mulching of the borrow source or other erosion control measures as may be approved by the Engineer.

The topsoil shall be removed and stockpiled at locations that will not interfere with the borrow operations and that meet the approval of the Engineer. Temporary erosion control measures shall be installed as may be necessary to prevent the erosion of the stockpile material. Once all borrow has been removed from the source or portion thereof, the stockpiled topsoil shall be spread uniformly over the source.

Where it is necessary to haul borrow material over existing roads, the Contractor shall use all necessary precautions to prevent damage to the existing roads. The Contractor shall also conduct his hauling operations in such a manner as to not interfere with the normal flow of traffic and shall keep the traffic lanes free from spillage at all times.

2. Owner Furnished Sources

Where borrow sources are furnished by the Owner the location of such sources will be as designated on the Drawings or as directed by the Engineer.

The Owner will furnish the necessary haul road right-of-way at locations designated by the Engineer. All haul roads required shall be built, maintained, and when directed by the Engineer, obliterated, at no cost to the Owner. Where the haul road is to be reclaimed for cultivation the Contractor shall plow or scarify the area to a minimum depth of 8 inches.

The borrow sources shall be left in a neat and presentable condition after use. All slopes shall be smoothed, rounded, and constructed not steeper than 3:1. Where the source is to be reclaimed for cultivation the source shall be plowed or scarified to a minimum depth of 8 inches, disc harrowed, and terraces constructed. The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided.

All sources shall be seeded and mulched in accordance with Section 02910.

3. Contractor Furnished Sources

Prior to the approval of any off-site borrow source(s) developed for use on this project, the Contractor shall obtain certification from the State Historic Preservation Officer of the State Department of Cultural Resources certifying that the removal of the borrow material from the borrow source(s) will have no effect on any known district, site building, structure, or object that is included or eligible for inclusion in the National Register of Historic Places. A copy of this certification shall be furnished to the Engineer prior to performing any work on the proposed borrow source.

The approval of borrow sources furnished by the Contractor shall be subject to the following conditions:

a. The Contractor shall be responsible for acquiring the right to take the material and any rights of access that may be necessary; for locating and developing the source; and any clearing and grubbing and drainage ditches necessary.

Such right shall be in writing and shall include an agreement with the Owner that the borrow source may be dressed, shaped, seeded, mulched, and drained as required by these Specifications after all borrow has been removed.

b. Except where borrow is to be obtained from a commercial source, the Contractor and the property owner shall jointly submit a borrow source development, use, and reclamation plan to the Engineer for his approval prior to engaging in any land disturbing activity on the proposed source other than material sampling that may be necessary. The Contractor's plan shall address the following:

(1) Drainage

The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided. If drainage is not practical, and the source is to serve as a pond, the minimum average depth below the water table shall be 4 feet or the source graded so as to create wetlands as appropriate.

(2) Slopes

The source shall be dressed and shaped in a continuous manner to contours which are comparable to and blend in with the adjacent topography, but in no case will slopes steeper than 3:1 be permitted.

(3) Erosion Control

The plan shall address the temporary and permanent measures that the Contractor intends to employ during use of the source and as a part of the reclamation. The Contractor's plan shall provide for the use of staged permanent seeding and mulching on a continual basis

while the source is in use and the immediate total reclamation of the source when no longer needed.

4. Maintenance

During construction and until final acceptance the Contractor shall use any methods approved by the Engineer which are necessary to maintain the work covered by this section so that the work will not contribute to excessive soil erosion.

- END OF SECTION -

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SECTION 02207

AGGREGATE MATERIALS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, equipment and materials required to complete all work associated with the installation of aggregate material beneath foundations, as backfill and as roadway subgrades and other related and incidental work as required to complete the work shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01090 - Reference Standards

B. Section 02200 - Earthwork

C. Section 02276 - Erosion and Sedimentation Control

D. Section 02510 - Paving and Surfacing

E. Section 02910 - Final Grading and Landscaping

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina State Highway Department Standard Specifications for Highway Construction.

2. ASTM C 127 Test for Specific Gravity and Absorption of Coarse Aggregate.

3. ASTM C 136 Test for Sieve Analysis of Fine and Coarse Aggregates.

4. ASTM C 535 Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Materials gradation and certification.

2. ASTM C127, ASTM C136, and ASTM C535 test results

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PART 2 -- PRODUCTS

2.01 CRUSHED STONE, SCREENED GRAVEL and AGGREGATE BASE COURSE (ABC)

A. Crushed stone or screened gravel shall meet the requirements of Aggregate Standard Size No. 57 or No. 67 as defined by SCDOT Standard Specifications.

B. ABC shall meet the requirements of ABC as defined by SCDOT Standard Specifications.

2.02 SELECT SAND

A. Select sand shall meet the requirements of Sections 1005 and 1014 of the NCDOT Standard Specifications for materials and gradation. The size used shall be Standard Size No. 2S or 2MS as listed and defined in Table 1005-2, "Aggregate Gradation", of the SCDOT Standard Specifications.

PART 3 -- EXECUTION

3.01 CRUSHED STONE, SCREENED GRAVEL AND AGGREGATE BASE COURSE (ABC)

A. Contractor shall install crushed stone, screened gravel and ABC in accordance with the SCDOT Standard Specifications and as shown on the Drawings and indicated in the Contract Documents.

1. Unless otherwise stated herein or shown on the Drawings, all mat foundations (bottom slabs) for the proposed structures shall have a blanket of crushed stone or ABC 6-inches thick minimum placed directly beneath the proposed mat. The blanket shall extend a minimum of 12 inches beyond the extremities of the mat.

2. For subgrade preparation at structures and structural fill, the foundation material shall be ABC where specifically specified on Drawings, otherwise, crushed stone or screened gravel shall be used.

3. For ground under drains, pipe bedding, and drainage layers beneath structures the coarse aggregate shall meet the requirements of aggregate standard Size No. 57 or No. 67, as defined by SCDOT Standard Specifications.

3.02 SELECT SAND

A. Contractor shall install select sand in accordance with the SCDOT Standard Specifications and as shown on the Drawings and indicated in the Contract Documents.

- END OF SECTION -

SECTION 02276

EROSION AND SEDIMENTATION CONTROL

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. The Contractor is responsible for implementing Best Management Practices (BMP's) to prevent and minimize erosion and resultant sedimentation in all cleared and grubbed areas during and after construction in accordance with South Carolina Department of Health and Environmental Control (SCDHEC) Stormwater Management requirements. This item covers the work necessary for the installation of structure and measures for the prevention and control of soil erosion. The Contractor shall furnish all material, labor and equipment necessary for the proper installation, maintenance, inspection, monitoring, reporting, and removal (where applicable) of erosion prevention and control measures as required to complete the work on the Drawings and specified herein.

B. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Drawings or established by the Engineer.

C. It is the intent of this Specification that the Contractor conducts the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized.

D. All work under this Contract shall be done in conformance with and subject to the limitations of the South Carolina Stormwater Management and Sediment Reduction Act (Section R.72-307) and local erosion control and stormwater management ordinances.

E. The following excerpts from the regulations are particularly important:

1. All sediment control measures shall be inspected at least once seven calendar days and after any storm event of greater than 0.5 inches of precipitation during any 24-hour period. All sediment control features shall be maintained until final stabilization has been obtained.

2. Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased, unless activity in that portion of the site will resume within 21 days.

F. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the erosion and sedimentation control devices will be adjusted on several occasions to reflect the current phase of construction. The construction schedule adopted by the Contractor will impact the placement and need for specific devices required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and off-site sedimentation. The location and extent of erosion and sedimentation control devices shall be revised at each phase of construction

that results in a change in either the quantity or direction of surface runoff from constructed areas. All deviations from the erosion and sedimentation control provisions shown on the Drawings shall have the prior acceptance of the Engineer.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02100 - Clearing, Grubbing, and Site Preparation

B. Section 02200 – Earthwork

C. Section 02910 - Final Grading and Landscaping

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of these specifications, all work hereunder shall conform to the applicable requirements of the referenced portions of the following documents, to the extent that the requirements therein are not in conflict with the provisions of this Section.

1. Section R.72-307, South Carolina Stormwater Management and Sediment Reduction Act.

2. SCDHEC Stormwater Management BMP Handbook, latest edition.

B. See Specification Section 01090 - Reference Standards.

1.04 REGULATORY COMPLIANCE

A. Contractor shall comply with requirements specified in the Contract Documents or by the Engineer. Contractor shall also comply with all other laws, rules, regulations, ordinances and requirements concerning soil erosion and sediment control established in the United States and the State of South Carolina.

1.05 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions Division 1 and Section 01300 - Submittals, the Contractor shall submit the following:

1. Name and location of all material suppliers.

2. Certificate of compliance with the standards specified above for each source of each material.

3. List of disposal sites for waste and unsuitable materials and all required permits for use of those sites.

1.06 GUARANTEE

A. All restoration and revegetation work shall be subject to the one-year guarantee period of the Contract as specified in the General Conditions.

PART 2 -- MATERIALS

2.01 MATERIALS

A. Materials for use in erosion and sedimentation control devices shall be in accordance with these specifications and the South Carolina Stormwater Management and Sediment Control Handbook.

2.02 SEDIMENT TRAPS

A. Temporary sediment traps shall be constructed as shown on the Contract Drawings and as specified herein. The temporary sediment traps shall be constructed and maintained in accordance with Part 3 of this Section and in accordance with the notes on the Drawings to the satisfaction of the Engineer until a vegetative ground cover has been established. The cost of the temporary sediment basins shall be included in the erosion control measures line item in the contract and shall include the excavation, grading, stone for erosion control, washed stone, geotextile, etc. and all maintenance activities required.

2.03 PIPE SLOPE DRAINS

A. Pipe Slope Drains shall be constructed as shown on the Contract Drawings and as specified herein. Pipe Slope Drains shall be constructed and maintained in accordance with Part 3 of this Section and in accordance with the notes on the Drawings to the satisfaction of the Engineer until a vegetative ground cover has been established. The cost of Pipe Slope Drains shall include the excavation and all maintenance and restoration activities required.

2.04 REINFORCED SILT FENCE

A. Reinforced Silt Fence shall be a woven geotextile filter fabric made specifically for sediment control. Filter fabric shall not rot when buried and shall resist attack from soil chemicals, alkalies and acids in the pH range from 2 to 13, and shall resist damage due to prolonged ultraviolet exposure. Filter fabric shall be of manufacturer acceptable to Anderson County Stormwater or equal. Reinforced Silt Fence shall be constructed and maintained in accordance with Part 3 of this Section and in accordance with the notes on the Drawings to the satisfaction of the Engineer until a vegetative ground cover has been established.

B. Filter fabric for the silt fence shall have the following minimum properties:

	Value	Test Method
Grab Tensile Strength	50 lbs	ASTM D 4632
Grab Elongation	15%	ASTM D 4632
Trapezoid Tear Strength	50 lbs	ASTM D 4533
Mullen Burst Strength	265 lbs	ASTM D 3786
Puncture Strength	58 lbs	ASTM D 4833

Retained Strength (500 hrs. accelerated UV exposure)	80%	ASTM D 4355
Filtration Efficiency	75%	VTM-51
Flow Rate	10 gal/min/ft^2	ASTM-D4491
Height	36 inches	

C. Posts for silt fence shall be steel and shall have the following properties:

ASTM Designation:	ASTM A702
Length:	5-Feet Long (T-Type)
Weight:	1.33#/Foot (min.)
Area of Anchor Plate:	14 Sq. In.

Note: Five (T) Fasteners shall be furnished with each post.

D. Wire Fabric for the silt fence shall have the following properties:

Wire Fabric Designation:	832-12-10-12.5 Class 1
Designation:	ASTM A116
Width:	32"
Number of Line Wires:	6
Stay Wire Spacing:	6"
Line and Stay Wires:	14 Ga.
Top and Bottom Wires:	14 Ga.
Wire Coating:	ASTM Class 1 Zinc Coating

Silt Fence shall be installed and maintained in accordance with Part 3 of this Section and the notes on the Drawings and to the satisfaction of the Engineer until the site has been stabilized. The cost of Silt Fence shall include the fabric, posts, wire fabric, excavation and all maintenance and restoration activities required.

2.05 STONE FOR EROSION CONTROL

A. The Contractor shall place Stone for Erosion Control as shown on the Drawings, as specified herein. The Stone for Erosion Control shall be as indicated on the Drawings.

2.06 RIP RAP

A. The Contractor shall place rip rap as shown on the Drawings and as specified in Section 804 of the South Carolina State Highway Department Standard Specifications for Rip Rap and Slope Protection. The stone for rip rap shall consist of field stone or rough unhewn quarry stone. The stone shall be sound, tough, dense, and resistant to the action of air and water. Neither the width nor thickness of individual stones shall be less than one-third their length. The rip rap shall be as shown on the Drawings.

2.07 GRAVEL AND RIPRAP FILTER BERM BASINS

A. Gravel and riprap filter berm basins shall be constructed as shown on the Drawings and as specified herein. The filter berm basins shall be constructed at the upstream end of all culverts as indicated and maintained in accordance with Part 3 of this Section and on the Drawings to the satisfaction of the Engineer until the site has been stabilized. The cost of the filter berms shall include the excavation, grading, stone for erosion control, riprap, etc. and all maintenance activities required.

2.08 TEMPORARY EROSION CONTROL LINING (RECM)

A. The Contractor shall place straw with net, curled wood, coconut fiber rolled erosion control matting (RECM) in areas indicated on the Drawings. Straw with net matting shall consist of clean wheat straw from agricultural crops made into a knitted straw mat that is machine assembled. The straw shall be evenly distributed throughout the mat. The straw with net mat shall be covered with a photodegradable synthetic mesh attached to the straw with degradable thread. The curled wood or coconut fiber mat shall consist of machine-produced mat of curled wood excelsior or coconut fiber with a majority of the fibers 6 inches or longer with consistent thickness and the fibers evenly distributed over the entire area of the mat. The top of the mat shall be covered with a biodegradable synthetic mesh. The mesh shall be attached to the curled wood excelsior or coconut fiber with photodegradable synthetic yarn.

B. The Contractor shall place the straw with net temporary channel and slope RECM where directed immediately after the channel or slope has been properly graded and prepared, fertilized, and seeded. If the mat is of single net construction, the netting shall be on top with the straw in contact with the soil.

C. The Contractor will immediately repair or replaced any section of temporary channel and slope RECM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.

D. Straw with net RECM shall be as manufactured by North American Green, American Excelsior, Contech, or equal with a minimum bare soil shear stress value as indicated on drawings.

2.09 PERMANENT EROSION CONTROL TURF REINFORCEMENT MAT (TRM)

A. The Contractor shall place synthetic channel and slope TRM in channel or on slopes as shown on the Drawings. The mat shall consist of entangled nylon, polypropylene or polyester monofilaments mechanically joined at their intersections forming a three-dimensional structure. The mat shall be crush-resistant, pliable, water-permeable, and highly resistant to chemical and environmental degradation.

B. The Contractor shall place the synthetic TRM where directed immediately after the channel or slope has been properly graded and prepared.

C. After the TRM has been placed, the area shall be properly fertilized and seeded as specified allowing the fertilizer and seeds to drop through the net.

D. The Contractor will immediately repair or replace any section of TRM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.

E. Synthetic TRM shall be as manufactured by Colbond Geosynthetics, Synthetic Industries, TC Mirafi, or equal matting with a minimum long-term unvegetated shear stress value as indicated on drawings.

2.11 TEMPORARY SLOPE DRAINS

A. Temporary slope drains shall be constructed as shown on the Drawings and as specified herein. The temporary slope drains shall be constructed and maintained in accordance with Part 3 of this Section and the notes on the Drawings to the satisfaction of the Engineer until the site has been stabilized. The cost of the temporary slope drains shall include the piping, earthwork, stone for erosion control, and all maintenance activities required.

2.12 GRAVEL CONSTRUCTION ENTRANCES

A. Gravel Construction Entrances shall be constructed as shown on the Drawings and as specified herein. Temporary gravel construction entrances shall be maintained in accordance with Part 3 of this Section and the notes on the Drawings to the satisfaction of the Engineer until the site has been stabilized. The cost of temporary gravel construction entrances shall include the gravel and all maintenance activities required.

2.13 TEMPORARY SOIL STABILIZER

A. The temporary agent for soil erosion control shall consist of an especially prepared highly concentrated powder which, when mixed with water, forms a thick liquid such as "Enviroseal 2001" by Enviroseal Corporation, "Terra Control" by Quattro Environmental, Inc., or "CHEM-CRETE ECO-110" by International CHEM-CRETE Corporation, and having no growth or germination inhibiting factors. The agent shall be used for hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a gelatinous crust.

PART 3 -- EXECUTION

3.01 INSTALLATION AND MAINTENANCE

A. Erosion and sedimentation control devices shall be established prior to or concurrent with the clearing operations in a given area. Where such practice is not feasible, the erosion and sedimentation control device(s) shall be established immediately following completion of the clearing operation.

B. The Contractor shall furnish the labor, materials and equipment required for routine maintenance of all erosion and sedimentation control devices. Maintenance shall be scheduled as required for a particular device to maintain the removal efficiency and intent of the device. Maintenance shall include but not be limited to 1) the removal and satisfactory disposal of accumulated sediment from traps or silt barriers and 2) replacement of filter fabrics used for silt fences and stone used in temporary sediment traps, stone filters, gravel construction entrances, etc.. Sediment removed from erosion and sedimentation control

devices shall be disposed of in locations that will not result in off site sedimentation as acceptable to the Engineer, at no additional cost to the Owner.

C. The Contractor shall provide temporary sedimentation traps at all locations shown on the Contract Drawings and for the settling of water pumped from the excavations or intercepted by drainage ditches for keeping water out of the excavations or to protect existing structures. The Contractor shall remove accumulated sediment from the traps as necessary to maintain their effectiveness or as indicated by the Engineer. Sediment material removed from the traps shall be disposed by the Contractor in locations that will not result in off-site sedimentation as acceptable to the Engineer, at no additional cost to the Owner.

1. Inspect temporary sediment traps after each period of significant rainfall. Remove sediment and restore the trap to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Place the sediment that is removed in a designated disposal area and replace the contaminated part of the gravel facing.

2. Check the structure for damage from erosion or piping. Periodically check the depth of the spillway to ensure it is a minimum of 1.5 ft. below the low point of the embankment. Immediately fill any settlement of the embankment to slightly above design grade. **Any riprap displaced from the spillway must be replaced immediately.**

3. After all sediment-producing areas have been permanently stabilized, remove the structure and all unstable sediment. Smooth the area to blend with the adjoining areas and stabilize properly.

D. The Contractor shall provide temporary diversions at all locations noted on the Contract Drawings. All temporary diversions shall outlet at a temporary sediment trap or other appropriate structure.

1. Inspect temporary diversions once a week and after every rainfall. Immediately remove sediment form the flow area and repair the diversion ridge. Carefully check outlets and make timely repairs as needed. When the area protected is permanently stabilized, remove the ridge and the channel to blend with the natural ground level and appropriately stabilize it.

E. Reinforced silt fence shall be erected as shown on the Drawings and specified herein. Reinforced silt fence shall be erected and maintained to the satisfaction of the Engineer until a vegetative ground cover has been established. Replacement of the filter fabric, if required by the Engineer, will be at the Contractor's expense.

1. Reinforced silt fence shall be erected around all catch basins which are located downstream from any construction work. Should any catch basins be indicated to be relocated or modified, silt fence shall be utilized until work is completed on the catch basins. Upon completion of the modification, the area shall be rough graded, as shown on the Drawings, until the end of the project, at which time final grading shall occur.

2. Inspect silt fence at least once a week and after each rainfall. Make any required repairs immediately.

3. Should the fabric of a silt fence collapse, tear, decompose or become in-effective, replace it promptly.

4. Remove sediment deposits as necessary to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout.

5. Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized. Removal of any silt fence shall be permitted only with the prior approval of the Engineer, or the local governing agency.

F. Riprap shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone. The placed riprap shall have a minimum depth of 24 inches. Type II Separator Geotextile shall be used under all riprap unless otherwise noted.

G. Riprap and stone for erosion control shall be dumped and placed in such manner that the larger rock fragments are uniformly distributed throughout the rock mass and the smaller fragments fill the voids between the larger fragments. Rearranging of individual stones by equipment or by hand shall only be required to the extent necessary to secure the results specified above, to protect structures from damage when rock material is placed against the structures, or to protect the underlying Separator Geotextile from damage during installation.

H. The Contractor shall provide gravel and riprap filter berm basins at all locations noted on the Contract Drawings.

1. Inspect gravel and riprap filter berm basins after each period of significant rainfall. Remove sediment and restore the basin to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Place the sediment that is removed in a designated disposal area and replace the contaminated part of the gravel facing.

2. Check the structure for damage from erosion or piping. **Any stone or riprap displaced from the berm must be replaced immediately.**

3. After all sediment-producing areas have been permanently stabilized, remove the structure and all unstable sediment. Smooth the area to blend with the adjoining areas and stabilize properly.

I. Engineer may direct the Contractor to place Straw with Net, Curled Wood or Coconut Fiber RECM's and Synthetic TRM's in permanent channels or on slopes at other locations not shown on Drawings.

1. All temporary and permanent channel and slope lining RECM's and TRM's shall be unrolled in the ditch in the direction of the flow of water. Temporary linings shall overlap the buried end of the downstream blanket by a minimum of 6 inches. Permanent linings shall overlap a minimum of 3 feet. All anchor and transverse

trenches shall be a minimum of 12 inches deep. All mat shall be stapled as per manufacturer's specifications.

2. During the establishment period, check grass, RECM and TRM-lined channels after every rainfall event. For grass-lined channel once grass is established, check periodically and after every heavy rainfall event. Immediately make repairs. It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping and scour holes. Give special attention to the outlet and inlet sections and other points where concentrated flow enters. Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times.

J. The Contractor shall provide temporary slope drains at all location noted on the Contract Drawings, and at other locations as may be directed by the Engineer.

1. Inspect the temporary slope drain and supporting diversion after every rainfall event and promptly make any necessary repairs. When the protected area has been permanently stabilized, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately.

K. The Contractor shall provide temporary gravel construction entrances at all locations noted on the Contract Drawings, and at all other locations as may be directed by the Engineer.

1. Maintain the gravel pad in a condition to prevent mud or sediment from leaving the construction site. This may require periodic topdressing with 2-inch stone. After each rainfall, inspect each construction entrance and clean out as necessary. Immediately remove all objectionable materials spilled, washed, or tracked onto public roadways.

L. The Contractor shall provide temporary or permanent ground cover adequate to restrain erosion on all disturbed areas that will be left unworked for periods exceeding 15 working or 30 calendar days.

1. Reseed and mulch temporary seeding areas where seedling emergence is poor, or where erosion occurs, as soon as possible. Do not mow. Protect from traffic as much as possible.

2. Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible.

3. **Reseeding –** If a stand has inadequate cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over-seed the stand. Consider seeding temporary, annual species if the time of year is not appropriate for permanent seeding.

4. If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

5. **Fertilization –** On the typical disturbed site, full establishment usually requires refertilization in the second growing season. Fine turf requires annual maintenance fertilization (See Table 6.12b, ESCPDM). Use soil tests if possible or follow the guidelines given for the specific seeding mixture (See Tables 6.11c through 6.11v, ESCPDM)

M. Additional Requirements

1. All storm sewer piping shall be blocked at the end of every working day until the inlet is constructed above grade.

2. All streets around the construction area shall be scraped as necessary to prevent accumulation of dirt and debris.

3. The Contractor shall provide adequate means to prevent any sediment from entering any storm drains, curb inlets (curb inlet filter box), ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of offsite areas. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed.

4. The Engineer may direct the Contractor to place any additional sediment and erosion control devices at other locations not shown on the Drawings.

5. Contractor shall also adhere to all requirements indicated in the notes for each erosion control detail on the Drawings.

3.02 INSPECTIONS AND MAINTENANCE

A. The Contractor shall designate a Qualified Person to perform inspections required by this Section. The following areas are to be inspected and maintenance performed, if needed, at least once every 7 calendar days and within 24 hours of a rainfall event that has a precipitation of 1/2 inch or greater.

1. Disturbed areas of the construction site that have not undergone final stabilization

2. Erosion and sediment control structures

3. All locations where vehicles enter or exit the site

4. Material storage and construction laydown areas that are exposed to precipitation and have not been finally stabilized

B. Immediate action will be taken to correct deficiencies to BMP's. The State reserves the right to stop all construction activities not related to maintaining BMP's until such deficiencies are repaired.

C. In areas that have been finally stabilized, inspections and, if necessary, maintenance by Contractor will occur at least once per month for the duration of the contract or project, whichever is longer.

D. During inspections the following will be observed and appropriate maintenance procedures taken:

1. The conformance to specifications and current condition of all erosion and sediment control structures

2. The effectiveness and operational success of all erosion and sediment control measures

3. The presence of sediments or other pollutants in storm water runoff at all runoff discharge points

4. If reasonably accessible, the presence of sediments or other pollutants in receiving waters

5. Evidence of off-site tracking at all locations where vehicles enter or exit the site

E. An inspection checklist must be completed during each inspection, dated, and signed by the Qualified Person conducting the inspection. Completed inspection checklist shall be kept on-site with the Contract Documents and submitted to the Engineer on a monthly basis. The Contractor will repair deficiencies within 24 hours of inspection.

3.03 REMOVAL OF TEMPORARY SEDIMENT CONTROL STRUCTURES

A. At such time that temporary erosion and control structures are no longer required under this item, the Contractor shall notify the Engineer of its intent and schedule for the removal of the temporary structures, and obtain the Engineer's approval in writing prior to removal. Once the Contractor has received such written approval from the Engineer, the Contractor shall remove, as approved, the temporary structures and all sediments accumulated at the removed structure shall be returned upgrade. In areas where temporary control structures are removed, the site shall be left in a condition that will restore original drainage. Such areas shall be evenly graded and seeded as specified in Section 02910 - Final Grading and Landscaping.

- END OF SECTION -

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SECTION 02445

CASING INSTALLATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The work under this section consists of providing all labor, materials, tools, equipment, and services required to perform all casing installation and related work as detailed on the Drawings and as described in these specifications.

B. The Contractor shall perform any general excavation required prior to placing casing pipe. Excess material resulting from excavation shall be disposed of by the Contractor in a suitable manner.

C. The Contractor shall provide all necessary access including access ladders, ramps, etc. to excavation prior to the commencement of casing installation.

D. The materials covered by these Specifications are intended to be standard materials of proven reliability and as manufactured by reputable manufacturers having experience in the production of such materials. The materials furnished shall be designed, constructed, and installed in accordance with the best practices and methods.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Division 2 - Sitework

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Requirements and Division 1, the Contractor shall submit the following:

1. Casing pipe shop drawings and material data from casing pipe manufacturer.

2. Excavation details including design and calculations for any sheeting or shoring utilized signed and sealed by a professional engineer registered in the State of South Carolina.

3. Construction sequence plan including casing placement procedures.

4. Casing Spacer manufacturer’s data and shop drawings.

5. Experience qualifications of contractor or subcontractor.

PART 2 -- MATERIALS

2.01 SPLIT STEEL CASINGS

In locations where a casing is required to be installed around an existing sanitary sewer, the Contractor shall install one of the following casing types:

A. Steel casing pipe as specified above, which is cut into two equal halves longitudinally (along the length of the pipe) by the supplier prior to shipment to the project site. The two halves shall be assembled over the existing water main, with casing spacers already installed; and the casing pipe shall be welded along the seam as specified herein. Only stainless steel casing spacers shall be used when this type of split casing is used, as plastic coatings could be damaged by welding of casing.

B. Split steel casings with weldable split sleeve and weld protection liner, to protect the carrier pipe and casing spacers, as manufactured by Westatlantic Tech Corp or approved equal. Except when flanged gasketed maintenance pipe casing is used, all split casings installed on carrier pipes made of PVC, HDPE, fiberglass and other materials potentially subject to damage from welding shall be split steel casings with weld protection liners unless otherwise approved by the Engineer.

C. In cases where required by the Drawings or otherwise approved by the Engineer, water tight split casings shall be flanged gasketed galvanized steel maintenance pipe with EPDM or NBR seals and bolted, flanged fasting joints. End seals shall be supplied by the casing manufacturer and shall be water tight unless otherwise indicated on the Drawings. Flanged gasketed maintenance pipe shall be as manufactured by Westatlantic Tech Corp or approved equal.

2.02 GROUT

A. Refer to Section 03600 – Grout.

2.03 CASING SPACERS

A. Contractor shall properly install and prevent the carrier pipe from floating by the use of casing spacers. Casing spacers shall be stainless steel, carbon steel or high-density polyethylene. The model of casing spacers shall correspond to the diameter of the carrier pipe and encasement pipe. Casing spacers shall fasten tightly onto the carrier pipe so that when the carrier pipe is being installed, the spacers will not move along the carrier pipe. Casing spacer placement along the carrier pipe shall be in accordance with the manufacturer's recommendations, unless shown otherwise on the drawings. Maximum distance between casing spacer and internal wall of casing pipe shall be 2-inches. Casing spacers shall be manufactured by Advance Products and Systems, Cascade Waterworks Mfg. Co., Pipeline Seal and Insulator, Public Works Marketing, or approved equal.

2.04 MASONRY WALL

A. One (1) course of standard brick and mortar masonry wall shall be constructed at each end of casing pipe, flush with casing pipe opening, once carrier pipe is installed. Brick shall have a nominal size 2-1/4 inches by 3-3/4 inch by 8 inch. Mortar shall be one part Portland cement blended with three parts sand (100% passing #4 sieve and minimum 95% passing No. 8 sieve) and have a minimum 7-day compressive strength of 500 psi. Prepared bag mixes are acceptable if approved by the Engineer.

B. Grout shall not be used to seal casing pipe ends.

PART 3 -- EXECUTION

3.01 INSTALLATION- GENERAL

A. The Contractor shall be responsible for the design, adequacy, and methodology for installation of the casing pipe. The Contractor shall submit the proposed method of installation, detailed layout information, methods to be implemented if unusual or adverse soil conditions (i.e.: running sand, water, etc.) are encountered during installation.

B. The recommended methods and details shown on the Drawings and specified herein, are intended to indicate the minimum acceptable standard of quality required for the casing installation. Other methods of installation, based on acceptable industry standards and techniques, may be acceptable for the installation.

C. All excavations shall allow for safe and adequate access for workmen, inspections, and materials and shall be of a size suitable to equipment and material handling requirements.

3.02 CARRIER PIPE INSTALLATION

A. For all casing installations the carrier pipe shall be installed with adequately designed and spaced pipe alignment guides "spiders", secured, and bulkheaded.

B. Concrete brick and mortar bulkheads with air and water vent holes shall be constructed at the terminal ends of the casing.

C. In addition, a Class B concrete cradle shall be provided from the end of the casing bulkhead to the first pipe joint outside the casing/tunnel.

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SECTION 02500

SURFACE RESTORATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Provide all labor, equipment, and materials necessary for final grading, topsoil placement, and miscellaneous site work not included under other Sections but required to complete the work as shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02200 - Earthwork

B. Section 02276 - Erosion and Sedimentation Control

C. Section 02910 - Final Grading and Landscaping

PART 2 -- MATERIALS

2.01 TOPSOIL

A. Topsoil shall meet the requirements of Section 02200 – Earthwork.

PART 3 -- EXECUTION

3.01 FINAL GRADING

A. Following approval of rough grading the subgrade shall be prepared as follows:

1. For riprap, bare soil 24 inches below finish grade or as directed by Engineer.

2. For topsoil, scarify 2-inches deep at 4 inches below finish grade.

3.02 TOPSOIL PLACEMENT

A. Topsoil shall be placed over all areas disturbed during construction under any contract except those areas which will be paved, graveled or rip rapped.

B. Topsoil shall be spread in place for lawn and road shoulder seed areas at a 4-inch consolidated depth and at a sufficient quantity for plant beds and backfill for shrubs and trees.

C. Topsoil shall not be placed in a frozen or muddy condition.

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D. Final surface shall be hand or mechanically raked to an even finished surface to finish grade as shown on Drawings.

E. All stones and roots over 4-inches and rubbish and other deleterious materials shall be removed and disposed of.

- END OF SECTION -

SECTION 02510

PAVING AND SURFACING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, equipment and materials and perform all operations in connection with the construction of asphalt concrete pavement, asphalt concrete overlay, reinforced concrete pavement, gravel roads, concrete curb and gutter, repair and reconstruction of existing asphalt concrete pavement, repair of existing gravel roads, and pavement markings complete as specified herein and as detailed on the Drawings.

B. All new roads including the replacement of portions of the existing roads shall be to the limits, grades, thicknesses and types as shown on the Drawings. Patches for pipe crossings and areas damaged during the construction work shall be asphalt and/or gravel, depending upon the material encountered, unless otherwise indicated.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1, Division 2 and Division 3 of these Specifications.

1.03 RELATED SECTIONS

A. Section 02200 - Earthwork

B. Section 03300 - Cast-In-Place Concrete

1.04 STANDARD SPECIFICATIONS

A. Except as otherwise provided in the Specifications or on the plans, all work shall be in accordance with the South Carolina Department of Transportation Standard Specifications for Highway Construction except that any reference to "SCDOT", "Department" or "Unit" shall mean the "Owner". When reference to these Specifications is intended, the description will be SCDOT Section _____ or SCDOT Specifications.

B. Except with the approval of the Engineer, the placing of concrete or asphalt concrete surface paving shall be subject to the Seasonal and Weather Restrictions set forth in SCDOT Specifications.

PART 2 -- MATERIALS

2.01 SELECT FILL

A. The Contractor shall place select fill as necessary to complete the embankments, shoulders, subgrade foundation and replacement for removed unsuitable material in accordance with SCDOT Section 205, and Section 02200, Earthwork.

2.02 CEMENT STABILIZED AGGREGATE BASE

A. All work, including materials, associated with Cement Stabilized Aggregate Base shall be in accordance with SCDOT Section 308, Cement Stabilized Aggregate Base, except that Articles 308.5 and 308.6, shall be deleted.

2.03 HOT MIX ASPHALT (HMA) PAVEMENT

A. All work, including materials, associated with Hot Mix Asphalt Pavement shall be in accordance with Section 401, Hot Mix Asphalt (HMA) Pavement, of the SCDOT Standard Specifications, except Articles 401.5 and 401.6 shall be deleted. A job mix formula will be developed by the Contractor for the particular materials the Contractor proposes to use.

B. The job mix formula shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.04 HMA INTERMEDIATE COURSE

A. All work, including materials, associated with HMA Intermediate Course shall be in accordance with Section 402, HMA Intermediate Course, of the SCDOT Standard Specifications, except Articles 402.5 and 402.6 shall deleted. A job mix formula will be developed by the Contractor for the particular materials the Contractor proposes to use.

B. The job mix formulas shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.05 HMA SURFACE COURSE

A. All work, including materials, associated with HMA Surface Course shall be in accordance with Section 403, HMA Surface Course, of the SCDOT Standard Specifications, except Articles 403.5 and 403.6 shall be deleted. A job mix formula will be developed by the Contractor for the particular materials the Contractor proposes to use.

B. The job mix formulas shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.06 PORTLAND CEMENT CONCRETE PAVEMENT

A. All work, including materials associated with rigid concrete pavement shall be in accordance with Section 03300, Cast-In-Place Concrete. Class A1 concrete shall be used. Placement shall be in accordance with Section 03300 and SCDOT Section 501, except that Articles 501.5 and 501.6 shall be deleted.

2.07 PORTLAND CEMENT CONCRETE PAVEMENT REINFORCING

A. Reinforcing, if specified, shall be as shown on the Structural Drawings and as specified under Section 03200, Reinforcing Steel.

2.08 CONCRETE CURB AND GUTTERS

A. Concrete shall be Class B in accordance with the requirements of Section 03300, Cast-In-Place Concrete, except that concrete shall be air-entrained to provide an air content of 6% ± 1.5%.

B. Premolded expansion joint filler for expansion joints shall conform to ASTM D 1751 and shall be 1/2-inch thick, minimum.

PART 3 -- EXECUTION

3.01 EMBANKMENT

A. The embankment shall be constructed in accordance with Section 02200, Earthwork.

3.02 SUBGRADE

A. The subgrade, where shown on the Drawings, shall be aggregate stabilized by the addition and mixing of coarse aggregate with the top 3-inches of subgrade. Following the application, the subgrade shall be formed true to crown and grade, and shall be compacted with a minimum of four (4) passes of a 15-ton vibratory roller to conform to the maximum densities determined by AASHTO T99 Standard Specifications.

3.03 CEMENT STABILIZED AGGREGATE BASE

A. The finished base course of all paving shall be Cement Stabilized Aggregate Base and shall be of the thickness shown on the Drawings, formed true to crown and grade. Gravel roads, including repair to existing gravel roads shall be Cement Stabilized Aggregate Base and shall be of the thicknesses shown on the Drawings, formed true to crown and grade.

3.04 HMA INTERMEDIATE COURSE

A. HMA Intermediate Course shall be placed in accordance with SCDOT Standard Specifications Sections 401 and 402. HMA Intermediate Course shall be compacted in accordance with SCDOT Standard Specifications. Thicknesses shall be as shown on the Drawings.

3.05 HMA SURFACE COURSE

A. Prior to placement of the HMA surface course, the base/intermediate course shall be inspected for damage or defects and repaired to the satisfaction of the Engineer. The surface of the base/intermediate course shall be approved by the Engineer.

B. The tack coat shall be applied to the surface of the approved base/intermediate course as described in SCDOT Section 401 and 403. Equipment for applying the tack coat shall be power-oriented pressure spraying or distributing equipment suitable for the materials to be applied and approved by the Engineer.

C. The HMA Surface Course shall be placed and compacted on the base/intermediate course in layers not to exceed 2-inches and at the rate of 110-pounds per square yard per inch. Surface Course shall be compacted in accordance with SCDOT Standard Specifications. Thicknesses shall be as shown on the Drawings.

3.06 PORTLAND CEMENT CONCRETE PAVEMENT

A. The subgrade and base course beneath portland cement concrete pavement shall be prepared in accordance with the applicable Sections of these Specifications and referenced Standard Specifications, except that the Contractor shall use an approved automatically controlled fine grading machine to produce final subgrade and base surfaces meeting the lines, grades, and cross sections (thicknesses) shown on the Drawings or established by the Engineer.

B. The surface of the base shall be damp at the time the concrete is placed. The Contractor shall sprinkle the base when necessary to provide a damp surface. The Contractor shall satisfactorily correct all soft areas in the subgrade or base prior to placing concrete.

C. Hauling over the base course shall not be allowed except where specifically permitted by and in writing by the Engineer. The Engineer may allow equipment dumping concrete to operate on the base to the extent and under the conditions the Engineer deems necessary to facilitate placing and spreading the concrete.

D. Installation of the concrete pavement shall be in accordance with the details shown on the Drawings and Division 3 - Concrete. The concrete pavement shall cure a minimum of ten (10) calendar days and until the concrete has attained a minimum flexural strength of 550 psi as indicated by flexural strength testing. The Contractor shall coordinate and pay for all flexural strength testing with a minimum of four (4) 6-inch by 6-inch by 20-inch beams for every fifty (50) cubic yards of pavement concrete installed.

E. Contraction joints shall be spaced at intervals as shown on the Drawings. Transverse contraction joints shall be formed by an approved joint insert. Expansion joints shall be placed when the pavement abuts a structure using 1-inch expansion joint material (filler) and sealant as specified herein.

3.07 CONCRETE CURB AND GUTTER

A. The expansion joint filler for concrete curb and gutters shall be cut to conform to the cross section of the curb. Expansion joints shall be spaced at intervals of not more than 25-feet. Formed control joints shall be installed at intervals not exceeding 10 feet. Depth of joint shall be 1/3 the thickness. Curved forms shall be used where radii are indicated; straight segments shall not be permitted. Upon removal of the forms, exposed curb faces shall be immediately rubbed down to a smooth and uniform surface. No plastering shall be permitted.

3.08 UNDERGROUND UTILITY LINES

A. Where an underground utility line is beneath the new roadway, the backfilling shall be carried out with special care, and the final consolidation shall be accomplished by a vibratory roller. Construction of the roadway over the trench shall be deferred as long as practicable.

3.09 JUNCTION WITH OTHER PAVING

A. Where new HMA pavement abuts existing HMA pavement, the existing pavement shall be cut back to insure obtaining the specified compaction of the new pavement courses and interlocking adjoining courses. Existing subbase courses shall be cut back from the subgrade level of the new pavement on a one-on-one slope into the existing pavement, and the HMA courses of the existing pavement shall be removed for an additional 6-inches back from the slope. The edge of the existing HMA courses shall be saw cut straight and true. The faces between new and existing asphalt courses shall receive an application of tack coat.

B. Where new concrete pavement abuts existing concrete or HMA paving, the existing paving shall be saw cut straight and true. An expansion joint of a 1/2-inch minimum thickness with filler material and sealant shall be placed between the new concrete pavement and the existing concrete or HMA paving.

3.10 HMA OVERLAY

A. Where HMA is proposed to be placed over an existing HMA or concrete surface, the surfaces shall be thoroughly cleaned by power brooming and a tack coat shall be applied in accordance with SCDOT Standard Specifications, prior to installing the overlay. The overlay shall be applied in accordance with Standard Specifications and Standard Details shown on the Drawings.

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SECTION 02604

UTILITY STRUCTURES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, equipment, and tools required for the design, fabrication, delivery and installment of utility structures and appurtenances in accordance with the Drawings and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02200 – Earthwork

B. Section 03200 – Reinforcing Steel

C. Section 03250 – Concrete Accessories

D. Section 03300 – Cast-in-Place Concrete

E. Section 03400 – Precast Concrete

F. Section 05540 – Castings

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ASTM C478 – Specification for Precast Reinforced Concrete Manhole Sections

2. ASTM C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

3. ASTM C990 - Specifications for Joints in Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

1.04 SUBMITTALS

A. Submit samples and/or Shop Drawings in accordance with Section 01300, Submittals.

B. In addition to items listed in Section 03400, Precast Concrete, Shop Drawings shall include, but not be limited to:

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1. Complete layout and installation Drawings and schedules with clearly marked dimensions.

2. Material certificates on all piping materials.

3. Structural design calculations sealed by a P.E. registered in the State of South Carolina. Design calculations for precast manholes and vaults shall include confirmation structures adequately resist flotation when they are totally empty and subjected to groundwater full height of structure.

4. Results of leakage test

PART 2 -- PRODUCTS

2.01 PRECAST MANHOLES, VAULTS, AND METER BOXES

A. Precast utility structures shall be furnished with waterstops, sleeves and openings as noted on the Drawings. Box out for wall pipes shall conform accurately to the sizes and elevations of the adjoining pipes. Precast utility structures shall be watertight and conform to the requirements of ASTM C 478 and ASTM C857 with the following modifications there to:

1. Materials shall conform to Section 03400, Precast Concrete.

2. Manholes shall meet the following:

a. Manhole section shall have an internal diameter of 4'-0", unless noted otherwise.

b. Minimum manhole wall thicknesses shall be 5 inches for 4 foot and 5 foot diameter manholes, 6 inches for 6 foot diameter manholes and 7 inches for 7 foot diameter manholes.

c. Manholes and utility structures shall include ballast concrete and/or other means necessary to insure manholes resist flotation when empty and subjected to groundwater full height of structure.

d. Precast manholes and utility structures shall be as manufactured by NC Products/Oldcastle, Tindall Products, or equal.

3. The date and name of manufacturer shall be marked inside each precast section.

4. No more than two lift holes may be cast or drilled in each section.

5. Dimensions shall be as shown on the Drawings.

6. Covers and frames shall be as specified in Section 2.13.

7. Mechanical Details such as piping, electrical, and other details shall be as shown on the Drawings.

B. Joints between manhole and utility structures riser sections and at base slabs shall be groove type.

2.02 BRICK

A. Brick shall be sound, hard-burned common brick conforming to ASTM C32, Grade MS.

2.03 MORTAR

A. Mortar shall conform to Section 04100 Mortar and Masonry Grout.

2.04 CONCRETE

A. Concrete shall conform to Section 03300, Cast-in-Place Concrete.

2.05 REINFORCING

A. Reinforcing shall conform to Section 03200, Reinforcing Steel.

2.06 PRECAST CONCRETE

A. Precast concrete shall conform to Section 03400, Precast Concrete.

2.07 CONCRETE BLOCK

A. Concrete block shall be solid, rectangular concrete masonry units conforming to ASTM C139.

2.08 CASTINGS

A. Castings shall conform to Section 05540, Castings. Casting shall be of the type and size indicated on the Drawings.

2.09 STEPS

A. Steps shall be constructed of Grade 60 steel reinforcing rod (min. 1/2-inch) and completely encapsulated with a wear resistant and chemical resistant rubber.

B. Each step shall have a minimum vertical load resistance of 800 pounds and a minimum pull-out resistance of 400 pounds.

C. The steps shall have 11-inch minimum tread width and shall be placed at 16-inches on center, as shown on the Drawings.

D. Steps shall be cast in place with the concrete.

E. Steps shall only be installed as shown on the Drawings or required in the Specifications.

2.10 JOINT SEALANT

A. Joint sealant shall be a preformed flexible sealant conforming to the requirements of ASTM C990, paragraph 6.2, Butyl Rubber Sealant. Joint sealant shall be Pro-Stik Butyl Sealant by Press-Seal, Butyl-Nek Join Sealant by Henry ,CS-102 Butyl Rubber Sealant for all Precast Structures by ConSeal, or equal.

2.11 FLEXIBLE RUBBER SLEEVE

A. The spring set type shall have a stainless steel interior power sleeve or expander and shall be the PSX assembly by Press-Seal Gasket Corporation, the Kor-N-Seal assembly by National Pollution Control Systems, or Lock Joint Flexible Manhole Sleeve by Interpace Corp.

B. The cast-in-place type shall conform to ASTM C923 and shall include stainless steel take up clamps.

C. Flexible seal assemblies shall permit at least an eight (8) degree deflection from the center line of the opening in any direction while maintaining a watertight connection.

2.12 RUBBER BLADDER

A The rubber bladder seal shall conform to ASTM C923 suitable for pressure testing at 10 psi minimum, with a 3/8 inch minimum wall thickness.

B. The rubber bladder seal shall contain an environmentally safe, anti-bacterial compound which turns into a high viscosity gel when in contact with pressurized water.

C. The rubber bladder seal shall be NPC Contour Seal by Kor-N-Seal, or equal.

2.13 COVERS AND FRAMES

A. Covers and frames shall comply with Section 05540, Castings and shall be provided by the utility structure manufacturer.

B. Manhole covers and frames shall meet the following requirements:

1. Locate so that there is ready access to the manhole steps

2. Clear opening shall be a minimum of 22 inches, unless otherwise indicated on the Drawings.

3. Watertight manhole frames and covers shall be suitable for 20 psi internal pressure and shall be Neenah Model R-1915, Type P or L or equal cast in place.

4. Non-watertight manhole covers shall be perforated and shall be Neenah Model R-1668, or equal.

5. Storm drain grated inlet frames and grates shall be Neenah R-1878-B7G, East Jordan Iron Works V5660, or equal.

6. Curb inlet frames and grates shall be Neenah R-3067, East Jordan Iron Works EJ 7030, or equal, and shall include frame, grate, and hood.

C. Vault covers shall have lifting handles and shall be bolted with stainless steel bolts complying with Section 05050, Metal Fastening.

D. All frames and covers shall be given one shop coat of asphalt or coal tar varnish, unless otherwise specified.

E. Frames and covers shall be identical throughout the Contract.

2.14 GRATES

A. Grates shall comply with Section 05540, Castings.

2.15 CONCRETE BALLAST

A. Concrete ballast shall be Class B concrete in conformance with Section 03300, Cast-in-Place Concrete. Ballast shall be provided as necessary to insure manhole resists flotation when empty and subjected to full height groundwater conditions.

2.16 FLEXIBLE JOINT SEALER

A. Flexible joint sealer shall be a rubber ring waterstop as manufactured by Fernco Joint Sealer Co., or equal.

2.17 EPOXY BONDING AGENT

A. Epoxy bonding agent shall conform to Section 03250, Concrete Accessories.

PART 3 -- EXECUTION

3.01 DESIGN CRITERIA

A. Minimum structural design loading for underground precast concrete vaults shall be as indicated in ASTM C857, unless otherwise noted herein. Precast items subjected to vehicular traffic shall be designed for H-20 traffic loading. Other precast items shall be designed for a vertical live load of 300 psf.

B. Walls of precast items shall be designed for a vertical surcharge of 100 psf.

C. Precast manholes and vaults shall be designed to resist flotation when totally empty and subjected to groundwater full height of the manhole/vault.

3.02 FABRICATION AND CASTING

A. Fabrication and casting shall conform to Section 03400, Precast Concrete, and to Section 03300, Cast-in-Place Concrete.

B. All base sections designated to receive concrete ballast and all electrical manholes shall extend monolithically a minimum of 6 inches beyond the outside face of the wall for the entire periphery. All other utility structures shall have a standard base.

C. Utility structures built around existing pipe shall have a cast-in-place base slab.

3.03 HANDLING, TRANSPORTING, AND STORING

A. Handling, transporting and storing of precast items shall comply with Section 03400, Precast Concrete.

3.04 INSTALLATION

A. Installation shall conform with Section 03400, Precast Concrete and with the manufacturer's recommendations or to Section 03300, Cast-in-Place Concrete.

B. Frames and covers or grates shall be set so that tops are at elevations indicated on the Drawings or flush with finished grade where no elevation is indicated.

C. Joints between riser sections shall be sealed with joint sealant.

D. All openings in utility structures shall have flexible rubber sleeves sized to fit the connecting pipe and installed to provide watertight joints in accordance with the manufacturer's recommendations. The interior of the sleeve shall be filled with Class B concrete.

E. Openings that are too large for flexible rubber sleeves shall utilize rubber bladder seals which are expanded by water injected using a pressure pump.

F. All units shall be installed plumb and level.

G. All lift holes and joints shall be filled with non-shrink grout conforming to Section 03600, grout inside and out.

H. The manhole frames shall be set to their required elevations either with grade rings or with two or three courses of brick masonry laid around the top of the upper wall section. Such brick work shall be given a 1-inch mortar coat on the inside and out.

I. Concrete ballast shall be placed so that it bears directly on the utility structure base against the outer wall monolithically encircling the structure for the full height indicated on the Drawings. Additional ballast may be required where the depth or elevation of the structure varies from the Drawings.

J. Brick or Concrete Block

Brick or concrete block shall be laid with broken joints and all horizontal and vertical joints filled with cement-sand mortar. Outside of walls shall be plastered with a minimum 1-inch thick coat of cement-sand mortar troweled smooth.

K. Connection to Existing Pipe

1. Verify the diameter and invert elevation of existing pipe to be connected to new utility structures prior to beginning work on the structures.

2. Provide adequate protection to prevent damage to the existing pipe.

3. Provide adequate means for plugging and/or transferring the existing flow in the pipe to allow for the construction of inverts and grouting.

4. Cut off the existing pipe sufficiently for connection to the new structure and remove.

5. Thoroughly clean all foreign matter and coat the pipe surface with epoxy adhesive where the pipe joins the new structure.

6. Install a flexible joint sealer around the pipe.

7. Grout inside and outside of wall penetration with nonshrink grout.

L. Backfill structures in accordance with Section 02200, Earthwork.

M. Clean all structures of any accumulation of silt, debris, or foreign matter and keep clean until final acceptance of the work.

N. Excavation shall conform to Section 02200, Earthwork.

O. Structure bases shall bear on a minimum of 8 inches of compacted stone unless otherwise indicated on the Drawings.

P. Channel Inverts

1. Inverts shall be placed using Class B concrete with forms sufficient to provide a smooth half-round shape as shown on the Drawings. Manhole bases employing full depth precast inverts are acceptable.

2. Where the slope of the line does not change through a manhole, a constant slope shall be maintained in the invert. Where slope changes occur within a given manhole, the transition shall be smooth and shall occur at the approximate center of the manhole.

3. Inverts shown on the Drawings are taken at the center of the manhole unless otherwise noted.

3.05 ADJUSTMENTS TO EXISTING UTILITY STRUCTURES

A. Adjust structures as indicated on the Drawings using concrete or cast iron adjustment rings by approved methods.

B. Clean covers and inlet castings of all foreign material and paint with one coat of coal tar epoxy.

3.06 ADJUSTING COLLARS AND FINAL ADJUSTMENTS

A. Adjusting collars shall be as shown on the Drawings. Final adjustments shall be made so that the manhole ring and cover will be smooth and flush with the finished grade of the adjacent surface, or as otherwise indicated on the Drawings for manholes shown above grade.

3.07 FLUSHING AND TESTING

A. Obstruction - After backfilling, all sewers shall be inspected for obstructions and shall be flushed with water. Flushing shall be a minimum velocity of 2.5 feet per second for a duration acceptable to the Engineer. Flushing shall remove all dirt, stones, pieces of wood and other debris which accumulated in the sewer during construction. The Contractor shall provide a means acceptable to the Engineer for removal of debris flushed from each section of sewer. If after flushing, any obstructions remain, they shall be removed at the Contractor's expense.

B. Visual Inspection - Sewer lines shall be visually inspected from every manhole by use of mirrors, television cameras, or other devices for visual inspection, and the lines shall all exhibit a fully circular pattern when viewed from one manhole to the next. Lines which do not exhibit a true line and grade or have structural defects shall be corrected to meet these qualifications.

C. Leakage - Sewers shall be tested for leakage. The program of testing shall fit the conditions as mutually determined by the Engineer and the Contractor. The Contractor shall take all necessary precautions to prevent any joints from drawing while the sewers or their appurtenances are being tested. The Contractor shall, at his own expense, correct any excess leakage and repair any damage to the pipe and their appurtenances, or to any structures resulting from or caused by these tests.

D. Leakage Test Procedure - Each section of sewer shall be tested by closing the lower end of the sewer to be tested and the inlet sewer of the upper manhole with stoppers and filling the pipe and manhole with water to a point 6 feet above the crown of the open sewer in the upper manhole, or, if ground water is present, 6 feet above the sections average adjacent ground water level as indicated by a monitor well installed adjacent to each manhole. The line shall be filled with water prior to testing and allowed to stand until the pipe has reached its maximum absorption, but not less than two (2) hours. After maximum absorption has been reached, the head shall be re-established and tested for at least six (6) hours maintaining the head specified above by measured additions of water. The sum of these additions shall be the leakage for the test period.

If ground water is present to a height of at least 6 feet above the crown of the sewer at the upper end of the pipe section to be tested, the leakage test may be made by measuring the rate of infiltration using a suitable weir or other measuring device approved by the Engineer. Whether the test is made by infiltration or exfiltration, the allowable leakage shall not exceed 100 gallons per day per inch of diameter per mile of sewer being tested.

Where the actual leakage exceeds the allowable, the Contractor shall discover the cause and correct it before the sewer will be accepted. For the purpose of this subsection, a section of sewer is defined as that length of sewer between successive manholes or special structures or stubouts for future connections.

E. Low Pressure Compressed Air Test - If the leakage cannot be located by infiltration or exfiltration testing, this type test may be used. The pipeline shall be considered acceptable, when tested at an average pressure of 3.0 psi greater than the average back pressure of any groundwater that may submerge the pipe, if the section under test does not lose air at a rate greater than 0.0030 cfm per sq. ft. of internal pipe surface.

F. Deflection Test - No sooner than thirty (30) days after final backfill installation, each section of PVC pipe shall be checked for vertical deflection using an electronic deflecto-meter or a rigid "Go-No-Go" device. Vertical deflection shall not exceed five (5) percent of the inside pipe diameter for PVC pipe.

Where the actual deflection exceeds the allowable, the Contractor shall discover the cause and correct it before the pipe will be acceptable. For the purpose of this subsection, a section of sewer is defined as that length of sewer between successive manholes or special structures or stubouts for future connections.

G. Cost of Testing and Repairs - Any and all work necessary to bring the line into conformance with the infiltration and deflection specifications shall be performed by the Contractor at no extra cost to the Owner. All apparent sources of infiltration and excessive deflection shall be repaired by the Contractor.

The Contractor shall provide all water, plugs, hoses, pumps, equipment, etc. necessary for the proper flushing and testing of the sewers.

- END OF SECTION -

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SECTION 02665

TEMPORARY BYPASS PUMPING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Under this item the Contractor is required to design and furnish all materials, labor, equipment, power, fuel, fuel storage, maintenance, etc. to implement a temporary pumping system for the purpose of diverting the existing flow around the work area on a daily basis, for the duration of the project.

B. The design, installation, and operation of the temporary pumping system shall be the Contractor's responsibility throughout the duration required. All components of the temporary bypass pumping system shall be provided by the Contractor.

C. The bypass system shall meet the requirements of all codes and regulatory agencies having jurisdiction. Contractor shall also be responsible for any fines imposed by local, state, and/or federal agencies for failure to maintain flows or contain spills and/or overflows.

D. The Contractor shall implement best management practices to prevent and minimize erosion and resultant sedimentation during all bypass pumping activities in accordance with Section 02276 – Erosion and Sedimentation Control.

1.02 SUBMITTALS

A. Bypass Pumping Plan: The Contractor shall submit to the Engineer for review and approval detailed drawings and descriptions outlining all provisions and precautions to be taken by the Contractor regarding the handling of existing wastewater flows. The plan must be specific and complete, including such items as schedules, locations, elevations, capacities of equipment, materials, and all other incidental items necessary and/or required to insure proper protection of the facilities, including protection of the access and bypass pumping locations from damage due to the discharge flows, and compliance with the requirements and permit conditions specified in these Contract Documents. No construction shall begin until all provisions and requirements have been reviewed by the Engineer. The plan shall include, but is not limited to, the following details:

1. Staging areas for pumps

2. Plugging methods and types of plugs

3. Number and size of pumps and basis of selection

4. Number, size, material, method of installation, and location of suction piping

5. Number, size, material, method of installation, and location of discharge piping

6. Bypass pump sizes, capacity, number of each size to be on site, and power requirements

7. Calculations of static lift, friction losses, and flow velocity (pump curves showing pump operating range are to be submitted)

8. Standby power generator size (if necessary), location

9. Thrust and restraint block sizes and locations

10. Sections showing suction and discharge pipe depth, embedment, select fill, and special backfill

11. Method of noise control for each pump and/or generator

12. Any temporary pipe supports and anchoring required

13. Design for access to bypass pumping locations indicated on the drawings

14. Selection of bypass pumping pipe size and material (include method of connections to pump and other piping)

15. Schedule for installation of and maintenance of bypass pumping lines

16. Describe how bypass pumping system will be monitored

17. Demonstrate upstream manholes will not overflow from surcharging and that upstream service connections will not be surcharged

18. Show discharge from force main will not surcharge downstream discharge manhole

19. Show 100% standby for pumps, power, controls, suction piping, and discharge piping

20. Show force main pipe material and thickness can withstand all normal operating and surge pressures with a safety factor of 2.0

21. Denote any conditions that will cause pumps to lose suction lift (prime) and describe procedures to rectify

22. Show that the emergency switchover from primary to secondary pumping will be automatic should equipment fail

23. Show suction and discharge piping is protected from possible damage from construction activities

24. Show any planned shifting of bypass equipment during construction

25. Provide for additional facilities as may be required at Specification 01520 – Maintenance of Plant Operation.

B. Sequence of Construction Plan: Furnish in accordance with Section 01300 – Submittals.

1. Contractor's Sequence of Construction defining work to be performed, including the following items:

   a. Definition of the start date, duration and end date

   b. Define activities to be performed by or witnessed by the Owner and date on which these activities are to be performed.

   c. Scheduling/timing of manufacturers field services, as specified.

2. Interruption of the operation of the existing facilities is required to perform the Work. Define the purpose for the interruption, date and time of interruption, and duration of interruption.

3. Provide complete list of equipment and material that is required to perform each segment of work.

PART 2 -- PRODUCTS

2.01 PUMPING EQUIPMENT

A. General:

1. Plant influent and effluent flows must be kept in service at all times unless approved by the Owner and Engineer. It is essential to the operation of the existing wastewater system that there shall be minimal interruption in the conveyance of flows throughout the duration of the project. To this end, the Contractor shall provide, maintain and operate all temporary facilities such as dams, plugs, pumping equipment (both primary and back-up units as required), conduits, all necessary power, and all other labor and equipment necessary to intercept the outfall flow before it reaches the point where it would interfere with his work, carry it past his work and return it to the existing system downstream of his work.

2. It is the Contractor's responsibility to provide equipment that is adequate for the performance of the Work under this Contract within the time specified. All equipment shall be kept in satisfactory operating condition, shall be capable of safely and efficiently performing the required Work, and shall be subject to review by the Owner's representative at any time within the duration of the Contract. All Work hereunder shall conform to the applicable requirements of the OSHA Standards for Construction.

3. Treatment plant operational requirements take precedence over Contractor activities. Therefore, interruption of treatment plant operations must be coordinated and are subject to the operational requirements of the Owner. Contractor shall assume that any interruption of treatment plant operations may be deferred by up to one (1) week from the requested time due to operational constraints.

4. The Contractor shall provide for utilities and services for its own operations. The Contractor shall furnish, install and maintain all temporary utilities during the contract period including removal upon completion of the Work.

5. Temporary Power

    a. Electrical supply for the temporary pumping shall be provided by a temporary unit sub-station and fusible switch in PMS-5. Contractor shall furnish and install the temporary substation and switch. Unit substation shall be sufficiently sized to provide all temporary pumps. All temporary equipment necessary which is not supplied electrically shall be diesel in accordance with the requirements below.

    b. Diesel Requirements

        i. Pumps requiring diesel power shall be equipped with sound attenuation equipment capable of reducing noise to 90 dB.

        ii. Contractor shall be responsible for providing and storing a sufficient quantity of diesel fuel on-site to continually operate the pumps for the duration of the temporary bypass pumping period.

        iii. Contractor shall check the pump fuel levels and shall re-fill the tanks to full capacity on a daily basis.

        iv. All pumps used must be constructed to allow dry running for long periods of time to accommodate the cyclical nature of the flows.

6. Each pump and driver shall be rated for continuous duty operation over the specified range of conditions without cavitating or overheating, and without excessive vibration or noise. In addition, each pump and driver shall be rated to operate intermittently at shut-off head against a closed discharge valve for periods of not less than 5 minutes without excessive cavitation, overheating, or vibration.

7. Furnish each pump with the necessary stop/start controls.

8. Contractor will not be permitted to stop or impede the main flows under any circumstances.

B. Temporary Bypass Pumping Requirements: The Contractor is responsible for the construction of the bypass facilities as described herein. Requirements for the bypass pumping system is as follows:

1. Bypass pumping system is required to be operated continuously during daily construction activities while the existing outfall pipeline is modified.

2. Contractor shall determine the number of pumps required to convey the bypass pumping flows listed in this Section. Contractor shall provide a backup unit for all components (pumps, power, controls, piping, etc.) of the bypass pumping system. The backup pump shall be piped into the suction and discharge headers and shall be on-line, isolated from the primary system by a valve.

3. The bypass pumping equipment shall be capable of pumping treated plant flows at the below rates (MGD).

	Min Flow Condition	Avg Daily Flow	Peak Flow
Rated Influent Capacity	9.0	18.0	45.0
RAS Flow Rate (100%)	9.0	18.0	18.0
Total Mixed Liquor Bypass Capacity	18.0	36.0	63.0

Contractor will have bypass pumping facilities manned at all time during operation.

4. Provide all pipeline plugs, pumps of adequate size to handle the peak daily flow, and temporary discharge piping to ensure that the total interceptor flow can be safely diverted around the work area while the sanitary sewer interceptor is modified. Wet weather flow projections are estimated. Contractor has the options of either sizing by-pass pumps for the wet weather flow, or provide contingency plan of placing pipe or keeping pipe in service in the event of wet weather flow.

5. The Contractor shall make all arrangements for bypass pumping during the time when the existing outfall pipeline is being modified for any reason.

6. Discharge piping shall be constructed of steel, ductile iron, or polyethylene pipe with positive, restrained joints. Under no circumstances will aluminum “irrigation” type piping or glued PVC pipe be allowed. Discharge hose will only be allowed in short sections and by specific permission from the Engineer.

7. Operation: The bypass pumps are to have variable capacity by controlling the speed of operation. Each pump shall have a separate control panel.

8. Provide pressure and vacuum gauges on the suction and discharge headers.

9. Provide pressure switches to start and stop the pumps and a pressure transmitter to vary the speed of the pumping units.

PART 3 -- EXECUTION

3.01 PREPARATION

A. The Contractor is responsible for locating any existing utilities in the area where the Contractor selects to locate the bypass pumps and pipelines. The Contractor shall locate his bypass pipelines to minimize any disturbance to existing utilities and shall obtain approval of the pipeline locations from the Owner and the Engineer. All costs associated with relocating utilities and obtaining all approvals shall be paid by the Contractor under Bid Item for By-Pass Pumping.

B. During bypass pumping operations, the Contractor shall protect the existing outfall pipeline, including the manholes, from damage inflicted by his equipment. The Contractor shall be responsible for all physical damage to the existing system caused by human or mechanical failure.

C. Contractor shall keep spare parts for pumps and piping on-site as requested. Adequate hoisting equipment for each pump and accessories shall be maintained on the site.

3.02 INSTALLATION AND REMOVAL

A. The Contractor shall pipe sections or make connections to the existing interceptor and construct temporary bypass pumping structures only at the access location and as may be required to provide an adequate suction conduit.

B. The temporary bypass pumping system shall be tested before placing the system in operation. Testing periods shall occur only between the hours of 8:30 a.m. and 3:00 p.m., Monday through Thursday. Testing of bypass pumping system shall NOT be allowed Friday through Sunday, on the Owner's scheduled Holidays, or on the day immediately prior to an Owner's scheduled Holiday. In addition, testing of bypass pumping system shall only be performed during the Owner's normally scheduled work days. Testing shall include leakage testing, pressure testing, and operational testing.

1. Leakage and pressure test: Contractor shall perform leakage and pressure testing for a minimum of two (2) hours on the pump duty suction piping and duty discharge piping in accordance with Article 3.03, Paragraph A. Contractor shall then remove the duty piping and shall install the standby suction piping and standby discharge piping and perform the same test for an additional two (2) hours.

2. Operation test: Contractor shall operate the temporary bypass pumping system for as long as necessary to demonstrate reliable operation of the entire system, including but not limited to pumps and controls, to the satisfaction of the Owner.

C. Plugging or blocking of outfall flows shall incorporate primary and secondary plugging devices. When plugging or blocking is no longer needed for performance of the work, the plugs are to be removed in a manner that permits the outfall flow to slowly return to normal without surge, surcharging, or causing other major disturbances downstream.

D. At the conclusion of the bypass pumping operation and once written permission is granted by the Owner and Engineer, Contractor shall remove all temporary bypass components and restore the site to original conditions to the satisfaction of the Owner and Engineer.

3.03 QUALITY CONTROL AND MAINTENANCE

A. Testing: Contractor shall perform leakage and pressure tests of the bypass pump suction and discharge piping using clean water prior to actual operation. Low pressure air test shall be conducted at a test pressure of 5 psi. The Engineer will be given 24 hours notice prior to testing.

A. Inspection: During the time the Contractor is working at the project site, Contractor shall inspect the bypass pumping system every two (2) hours to ensure that the system is working correctly and shall keep a written log of the pump inspection results. Contractor shall inspect the bypass pumping system a minimum of either one (1) time per day or as often as necessary to ensure full fuel tanks for the bypass pumps.

B. Maintenance Service: Contractor shall insure that the temporary pumping system is properly maintained and a responsible and competent mechanic/operator shall be on call at all times.

3.04 SEQUENCE OF CONSTRUCTION

A. Contractor shall propose a Sequence of Construction incorporating all constraints detailed in this Section and shall secure concurrence of Owner prior to starting work.

B. The Contractor shall submit a construction plan and schedule, which details the methods, means, techniques, and sequences to be used to establish a base element of surety against a wastewater spill, to the Engineer for review and approval by the Owner at least two (2) weeks prior to any connections to existing pipes or structures. Such plan shall provide assurance against a wastewater spill, with at least one level of backup. Any and all fines or fees imposed upon the Owner resulting from spills or process interruptions shall be assessed solely upon Contractor. One week prior to connections being made to existing structures or pipes, a coordination meeting shall be held between the Contractor, Engineer, and Owner to discuss the construction plan previously submitted by the Contractor.

C. Schedule of construction, interconnecting details, and other revisions necessary for proper interfacing of the Work are to be subsequently modified by Contractor accounting for results of said coordination meeting. The Engineer and Owner are to be notified 24 hours prior to any actual interruptions or connections being made. Begin no work prior to securing Owner's approval of respective connection plan and work schedule.

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SECTION 02910

FINAL GRADING AND LANDSCAPING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all labor, equipment, and materials necessary for final grading, topsoiling, seeding, and miscellaneous site work not included under other Sections, but required to complete the work as shown on the Drawings and specified herein. Under this Section, all areas of the project site disturbed by excavation, materials storage, temporary roads, etc., shall be reseeded as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02276 - Erosion and Sedimentation Control.

B. Section 02500 - Surface Restoration.

1.03 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Product Data

2. Certification of all materials

3. Three (3) copies of composition and germination certification and of test results for grass seed.

PART 2 -- PRODUCTS

2.01 CONTRACTOR'S RESPONSIBILITIES

A. Furnish and submit certification for the materials used as specified in the General Conditions, Division 1 and Division 2.

2.02 TOPSOIL

A. Upon completion and approval of the rough grading, the Contractor shall place the topsoil over all areas disturbed during construction under any contract except those areas which will be paved, graveled or rip rapped. Topsoil shall not be placed in a frozen or muddy condition and shall contain no toxic materials harmful to grass growth. Topsoil shall be as defined under Section 02200, Earthwork.

2.03 WATER

A. Water shall be furnished to the Contractor by the Owner from existing facilities as directed by the Engineer.
B. The Contractor shall furnish all hoses and connections necessary to complete the landscaping work.

2.04 FERTILIZER

A. Fertilizer shall be a complete commercial fertilizer with components derived from commercial sources. Fertilizer analysis shall be determined from field soil sampling in appropriate number taken by the Contractor and analyzed by the S.C. Department of Agriculture or other independent laboratory. Contractor shall furnish fertilizer in accordance with the recommendations of the S.C. Department of Agriculture.

B. One-quarter of the Nitrogen shall be in the form of nitrates, one-quarter in the form of ammonia salts, and one-half in the form of natural organic Nitrogen. Available Phosphoric Acid shall be free from superphosphate, bone, or tankage. Potash shall be Sulphate of Potash. Elements shall conform to the standards of Association of Official Agricultural Chemists.

C. Fertilizer shall be delivered in standard size bags marked with the weight, analysis of contents, and the name of the manufacturer. Fertilizer shall be stored in weatherproof storage areas and in such a manner that its effectiveness will not be impaired.

2.05 LIME

A. At least 50% shall pass a No. 200 U.S.S. mesh sieve. At least 90% shall pass a No. 100 U.S.S. mesh sieve and 100% shall pass a No. 10 U.S.S. mesh sieve. Total carbonates shall not be less than 80% or 44.8% Calcium Oxide equivalent. For the purpose of calculation, total carbonates shall be considered as Calcium Carbonate.

2.06 GRASS SEED

A. The Contractor shall furnish the kinds and amounts of seed to be seeded in all areas disturbed by the construction work. All seed shall be labeled to show that it meets the requirements of the South Carolina Seed Law. All seed must have been tested within six (6) months immediately preceding the planting of such material on the job.

B. The inoculant for treating legume seed shall be a pure culture of nitrogen-fixing bacteria prepared specifically for the species. Inoculants shall not be used later than the date indicated on the container. The quality of the seed shall conform to the following:

Type	Minimum Seed Purity (%)	Minimum Germination (%)	Maximum Weed Seed (%)
Common Bermuda	98	85	0.25
Hybrid Rye	98	85	0.10
Bahia Grass	98	85	0.25
Millet	98	85	0.50
Sericea Lespedeza			
Scarified	98	85	0.50
Unscarified	98	85	0.50

C. Scarified Lespedeza may contain 20% hard seed and unscarified 50% hard seed. Seed containing prohibited noxious weed seed shall not be accepted. Seed shall be in conformance with S.C. Seed Law restrictions for restricted noxious weeds.

D. Seed mixtures to be used on the project shall be as follows:

Permanent (March 15 – August 31)

10#/acre	Browntop Millet
20#/acre	Bahia Grass
6#/acre	Common Bermuda (hulled)
40#/acre	Sericea Lespedeza

Permanent (September 1 – November 15)

10#/acre	Rye, Grain
40#/acre	Bahia Grass
5#/acre	Clover, Crimson (Annual)

Add 1.5 tons/acre ground course textured agricultural limestone
Add 1,000 lb/acre 10-10-10 fertilizer
Add 4,000 lb/acre straw mulch

Temporary (March 15 – August 31)

40#/acre	Browntop Millet or Japanese Millet

Temporary (September 1 – March 15)

56#/acre	Rye, Grain
or	
75#/acre	Rye, Oats

Temporary (September 1 – April 15)

50#/acre	Rye Grass

Add 3,000 lb/acre straw mulch

2.07 WOOD CELLULOSE FIBER MULCH

A. For use in hydroseeding grass seed in combination with fertilizers and other approved additions, shall consist of especially prepared wood cellulose fibers such as "Conwed", "Mat-Fiber", or equal, and have no growth or germination inhibiting factors, and be dyed green.

B. The wood cellulose fiber shall have the additional characteristic of dispersing rapidly in water to form a homogeneous slurry and remain in such state when agitated in the hydraulic mulching unit, or adequate equal, with the specified materials.

C. When applied, the wood cellulose fiber with additives will form an absorptive mat but not a plant inhibiting membrane, which will allow moisture, natural or mechanical, to percolate into underlying soil.

D. The mulch shall be supplied, compressed in packages containing 50 pounds of material having an equilibrium air dry moisture content at time of manufacture of 12% plus or minus 3%. Wood cellulose fiber mulch shall be stored in a weatherproof storage area and in such a manner that effectiveness will not be impaired.

2.08 STRAW MULCH

A. Straw used for mulch shall be small grain hay. Hay shall be undamaged, air dry, threshed straw, free of undesirable weed seed. Straw mulch is not required for seeded areas treated with a temporary soil stabilizer.

2.09 TEMPORARY SOIL STABILIZER

A. The temporary agent for soil erosion control shall consist of an especially prepared highly concentrated powder which, when mixed with water, forms a thick liquid such as "Enviroseal 2001" by Enviroseal Corporation, "Terra Control" by Quattro Environmental, Inc., or "CHEM-CRETE ECO-110" by International CHEM-CRETE Corporation, and having no growth or germination inhibiting factors. The agent shall be used for hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a gelatinous crust.

2.10 ROLLED EROSION CONTROL PRODUCTS

A. The rolled erosion control products (RECPs) shall be as specified in Section 02276 - Erosion and Sedimentation Control.

2.11 RIPRAP AND HERBICIDES

A. Furnish and install sufficient quantity of landscape gravel or riprap to cover over the ground to a minimum 4-inch depth for gravel and 24-inch depth for riprap, unless otherwise noted, or indicated on the Drawings. Also furnish and apply an approved herbicide to the subgrade surface just prior to installing the landscape gravel or riprap.

B. During placing, the stone shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone.

C. All topsoil and vegetative matter shall be removed from the subgrade surfaces prior to the application of the weed killer (herbicide) and to the placement of landscape gravel or riprap. Apply commercial-type herbicide as preemergence control of miscellaneous grasses and broadleaf weeds in granular or liquid form such as "Treflan", "Dymid", or equal. Methods and rates of application shall be in strict compliance to manufacturer's directions and acceptable to the Engineer.

D. The herbicide selected shall be safe for use around ornamental plantings, have long-lasting weed control, and shall be resistant to leaching away under excessive rainfall.

E. A second application of the herbicide shall be made on the surface of the landscape gravel or riprap sometime after the first six (6) months, but not later than 12-months. Same methods and rates apply as specified previously.

PART 3 -- EXECUTION

3.01 GRADING

A. After approval of the rough grading, the Contractor shall commence his preparations of the subgrade for the various major conditions of the work as follows:

1. Bare soil for riprap area at subgrade (24-inches below final grade, or as directed by the Engineer).

2. Topsoil for lawn and road shoulder seed area - scarify 2-inch depth of subgrade (4-inches below final grade) prior to placing topsoil.

B. Final surface grading of the topsoiled, landscape graveled, and riprapped areas shall be mechanically raked or hand raked to an even finished surface alignment.

3.02 TOPSOIL

A. Topsoil shall be spread in place for quantity required for lawn and road shoulder seed areas at 4-inch consolidated depth, and sufficient quantity for certain plant beds and backfill for shrubs and trees as specified.

3.03 SEEDBED PREPARATION

A. Contractor shall prepare all areas to receive temporary or permanent seeding measures prior to planting.

B. Topsoil shall be placed in areas to be seeded and roughened with tracked equipment or other suitable measures. Slopes steeper than 3:1 may be roughened by grooving, furrowing, tracking, or stairstep grading. Slopes flatter than 3:1 should be grooved by disking, harrowing, raking, operating planting equipment on the contour.

C. Soil amendments including, but not limited to, lime and fertilizer shall be spread as necessary, and at the rates specified in this Section. Seeding shall be as per the type and rates specified in this Section. Seed shall be broadcast as soon as possible following roughening, before surface has been sealed by rainfall.

3.04 HYDROSEEDING AND GRASS

A. The Contractor shall grow a stand of grass by hydroseeding method on all disturbed areas. The Contractor shall be responsible for the satisfactory growth of grass throughout the period of the one-year guarantee.

B. The Contractor's work shall include the preparation of the topsoil and bare soil seed bed, application of fertilizer, limestone, mulching, inoculant, temporary soil stabilizer, watering, and all other operations necessary to provide a satisfactory growth of sod at the end of the one-year maintenance period. Areas without satisfactory sod at the end of one (1) year shall be replanted until satisfactory growth is obtained and acceptable to the Engineer.

C. All areas to be seeded shall be done by the hydraulic seeding method including all additives and amendments required. A "Reinco", "Finn", or "Bowie" type hydromulcher with adjustable nozzles and extension hoses, or equal, shall be utilized. General capacity of tank should range from 500 to 2,500 gallons, or as approved by the Engineer.

D. Hydraulic seeding shall be carried out in three steps. Step one shall consist of the application of lime. In step two the seed mixture shall be mixed with the fertilizer, wood cellulose fiber mulch, and any required inoculants and applied to the seed bed. Step three shall consist of application of top dressing during the first spring or fall, whichever comes first, after step two.

E. Top dressing shall consist of a commercial grade fertilizer plus Nitrogen or other analysis as may be recommended by soil testing. Types and application rates of seed mixtures, lime, fertilizer, and wood cellulose fiber mulch, shall be as shown in the Seeding Schedule.

F. Ingredients for the mixture and steps should be dumped into a tank of water and thoroughly mixed to a homogeneous slurry and sprayed out under a minimum of 300-350 pounds pressure, in suitable proportions to accommodate the type and capacity of the hydraulic machine to be used. Applications shall be evenly sprayed over the ground surface. The Contractor shall free the topsoil of stones, roots, rubbish, and other deleterious materials and dispose of same off the site. The bare soil, except existing steep embankment area, shall be rough raked to remove stones, roots, and rubbish over 4-inches in size, and other deleterious materials and dispose of same off the site.

G. No seeding should be undertaken in windy or unfavorable weather, when the ground is too wet to rake easily, when it is in a frozen condition, or too dry. Any bare spots shown in two to three weeks shall be recultivated, fertilized at half the rate, raked, seeded, and mulched again by mechanical or hand broadcast method acceptable to the Engineer.

H. Areas that have been seeded with a temporary seed mixture shall be mowed to a height of less than 2-inches and scarified prior to seeding with the permanent seed mixture.

I. The Contractor shall provide, at his own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.

J. The Contractor shall water newly seeded areas of the lawn and road shoulder mix once a week until the grasses have germinated sufficiently to produce a healthy turf, or unless otherwise directed by the Engineer. Each watering shall provide three (3) gallons per square yard. The Contractor shall furnish all necessary hoses, sprinklers, and connections.

K. The first and second cutting of the lawn grasses only shall be done by the Contractor. All subsequent cuttings will be done by the Owner's forces in a manner specified by the Contractor.

3.05 DITCH AND SWALE EROSION PROTECTION

A. All ditches and swales indicated on the Drawings shall be lined with a rolled erosion control product (RECP). The area to be covered shall be properly graded and hydroseeded before the RECP is installed. Installation shall be in accordance with Section 02276, Erosion and Sedimentation Control.

3.06 MAINTENANCE

A. The Contractor shall be responsible for maintaining all seeded areas until 100% construction completion has been achieved. Maintenance shall include but not be limited to, annual fertilization, mowing, repair of seeded areas, irrigation, and weed control. The Contractor shall provide, at his own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.

B. Annual fertilization shall consist of an application of 500#/acre of 10-10-10 commercial grade fertilizer, or its equivalent and 60#/acre of nitrogen in early fall, or other analysis as may be determined by soil test. Annual fertilization shall be in addition to top dressing and shall be performed by the Contractor each fall season after planting until the work is substantially complete.

C. Mowing shall be scheduled so as to maintain a minimum stand height of 4-inches or as directed by the Engineer. Stand height shall be allowed to reach 8 to 10-inches prior to mowing.

D. All seeded areas shall be inspected on a regular basis and any necessary repairs or reseedings made within the planting season, if possible. If the stand should be over 60% damaged, it shall be re-established following the original seeding recommendations.

E. Weed growth shall be maintained mechanically and/or with herbicides. When chemicals are used, the Contractor shall adhere strictly to the instructions on the label of the herbicide. No herbicide shall be used without prior approval of the Engineer.

3.07 CLEANUP

A. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

B. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

- END OF SECTION -

SECTION 03100

CONCRETE FORMWORK

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Provide materials, labor, and equipment required for the design and construction of all concrete formwork, bracing, shoring and supports in accordance with the provisions of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03200 - Reinforcing Steel

B. Section 03250 - Concrete Accessories

C. Section 03290 - Joints in Concrete

D. Section 03300 - Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. ACI 318 - Building Code Requirements for Structural Concrete

3. ACI 301 - Specifications for Structural Concrete for Buildings

4. ACI 347 - Recommended Practice for Concrete Formwork

5. U.S. Product Standard for Concrete Forms, Class I, PS 1

6. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Manufacturer's data on proposed form release agent

2. Manufacturer's data on proposed formwork system including form ties

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1.05 QUALITY ASSURANCE

A. Concrete formwork shall be in accordance with ACI 301, ACI 318, and ACI 347.

PART 2 -- PRODUCTS

2.01 FORMS AND FALSEWORK

A. All forms shall be smooth surface forms unless otherwise specified.

B. Wood materials for concrete forms and falsework shall conform to the following requirements:

1. Lumber for bracing, shoring, or supporting forms shall be Douglas Fir or Southern Pine, construction grade or better, in conformance with U.S. Product Standard PS20. All lumber used for forms, shoring or bracing shall be new material.

2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Pine high density overlaid (HDO) plywood manufactured especially for concrete formwork and shall conform to the requirements of PS1 for Concrete Forms, Class I, and shall be edge sealed. Thickness shall be as required to support concrete at the rate it is placed, but not less than 5/8-inch thick.

C. Other form materials such as metal, fiberglass, or other acceptable material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line and grade indicated may be submitted to the Engineer for approval, but only materials that will produce a smooth form finish equal or better than the wood materials specified will be considered.

2.02 FORMWORK ACCESSORIES

A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to insure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties, or of other removable form-tie fasteners having a circular cross-section, shall not exceed 7/8-inch, and all such fasteners shall be such as to leave holes of regular shape for reaming.

B. Form ties for water-retaining structures shall have integral waterstops. Removable taper ties may be used when acceptable to the Engineer. A preformed mechanical EPDM rubber plug shall be used to seal the hole left after the removal of the taper tie. Plug shall be X-Plug by the Greenstreak Group, Inc., or approved equal. Friction fit plugs shall not be used.

C. Form release agent shall be a blend of natural and synthetic chemicals that employs a chemical reaction to provide quick, easy and clean release of concrete from forms. It shall not stain the concrete and shall leave the concrete with a paintable surface. Formulation of the form release agent shall be such that it would minimize formation of "bug holes" in cast-in-place concrete.

PART 3 -- EXECUTION

3.01 FORM DESIGN

A. Forms and falsework shall be designed for total dead load, plus all construction live load as outlined in ACI 347. Design and engineering of formwork and safety considerations during construction shall be the responsibility of the Contractor.

B. Forms shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. The maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members.

C. All forms shall be designed for predetermined placing rates per hour, considering expected air temperatures and setting rates.

3.02 CONSTRUCTION

A. The type, size, quality, and strength of all materials from which forms are made shall be subject to the approval of the Engineer. No falsework or forms shall be used which are not clean and suitable. Deformed, broken or defective falsework and forms shall be removed from the work.

B. Forms shall be smooth and free from surface irregularities. Suitable and effective means shall be provided on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Joints between the forms shall be sealed to eliminate any irregularities. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to a practical minimum.

C. Forms shall be true to line and grade, and shall be sufficiently rigid to prevent displacement and sagging between supports. Curved forms shall be used for curved and circular structures. Straight panels joined at angles will not be acceptable for forming curved structures. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly-placed concrete. Facing material shall be supported with studs or other backing which shall prevent both visible deflection marks in the concrete and deflections beyond the tolerances specified.

D. Forms shall be mortar tight so as to prevent the loss of water, cement and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1 to 1-1/2 inch diameter polyethylene rod held in position to the underside of the wall form.

E. All vertical surfaces of concrete members shall be formed, and side forms shall be provided for all footings, slab edges and grade beams, except where placement of the concrete against the ground is called for on the Drawings. Not less than 1-inch of concrete shall be added to the thickness of the concrete member as shown where concrete is permitted to be placed against trimmed ground in lieu of forms. Such permission will be granted only for members of comparatively limited height and where the character of the ground is such that

it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.

F. All forms shall be constructed in such a manner that they can be removed without hammering or prying against the concrete. Wood forms shall be constructed for wall openings to facilitate loosening and to counteract swelling of the forms.

G. Adequate clean-out holes shall be provided at the bottom of each lift of forms. Temporary openings shall be provided at the base of column forms and wall forms and at other points to facilitate cleaning and observation immediately before the concrete is deposited. The size, number and location of such clean-outs shall be as acceptable to the Engineer.

H. Construction joints shall not be permitted at locations other than those shown or specified, except as may be acceptable to the Engineer. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. For flush surfaces at construction joints exposed to view, the contact surface of the form sheathing over the hardened concrete in the previous placement shall be lapped by not more than 1 inch. Forms shall be held against hardened concrete to prevent offset or loss of mortar at construction joints and to maintain a true surface.

I. The formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads. Set forms and intermediate screed strips for slabs accurately to produce the designated elevations and contours of the finished surface. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment. When formwork is cambered, set screeds to a like camber to maintain the proper concrete thickness.

J. Positive means of adjustment (wedges or jacks) for shores and struts shall be provided and all settlement shall be taken up during concrete placing operation. Shores and struts shall be securely braced against lateral deflections. Wedges shall be fastened firmly in place after final adjustment of forms prior to concrete placement. Formwork shall be anchored to shores or other supporting surfaces or members to prevent upward or lateral movement of any part of the formwork system during concrete placement. If adequate foundation for shores cannot be secured, trussed supports shall be provided.

K. Runways shall be provided for moving equipment with struts or legs. Runways shall be supported directly on the formwork or structural member without resting on the reinforcing steel.

3.03 TOLERANCES

A. Unless otherwise indicated in the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in ACI 117.

B. Structural framing of reinforced concrete around elevators and stairways shall be accurately plumbed and located within 1/4 in. tolerance from established dimensions.

C. The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used for reference purposes to check tolerances. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by Contractor's personnel and by the Engineer and shall be in sufficient number and properly installed. During concrete placement, the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.

D. Regardless of the tolerances specified, no portion of the building shall extend beyond the legal boundary of the building.

3.04 FORM ACCESSORIES

A. Suitable moldings shall be placed to bevel or round all exposed corners and edges of beams, columns, walls, slabs, and equipment pads. Chamfers shall be 3/4 inch unless otherwise noted.

B. Form ties shall be so constructed that the ends, or end fasteners, can be removed without causing appreciable spalling at the faces of the concrete. After ends, or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than 2 inches from the formed face of the concrete that is exposed to water or enclosed surfaces above the water surface, and not less than 1 inch from the formed face of all other concrete. Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar as specified in Section 03350 - Concrete Finishing. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete member. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal will not be permitted. No snap ties shall be broken off until the concrete is at least three days old. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste.

3.05 APPLICATION - FORM RELEASE AGENT

A. Forms for concrete surfaces that will not be subsequently waterproofed shall be coated with a form release agent. Form release agent shall be applied on formwork in accordance with manufacturer's recommendations.

3.06 INSERTS AND EMBEDDED ITEMS

A. Sleeves, pipe stubs, inserts, anchors, expansion joint material, waterstops, and other embedded items shall be positioned accurately and supported against displacement prior to concreting. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

3.07 FORM CLEANING AND REUSE

A. The inner faces of all forms shall be thoroughly cleaned prior to concreting. Forms may be reused only if in good condition and only if acceptable to the Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture.

Unused tie rod holes in forms shall be covered with metal caps or shall be filled by other methods acceptable to the Engineer.

3.08 FORM REMOVAL AND SHORING

A. Forms shall not be disturbed until the concrete has attained sufficient strength. Sufficient strength shall be demonstrated by structural analysis considering proposed loads, strength of forming and shoring system, and concrete strength data. Shoring shall not be removed until the supported member has acquired sufficient strength to support its weight and the load upon it. Members subject to additional loads during construction shall be adequately shored to sustain all resulting stresses. Forms shall be removed in such manner as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.

B. Provided the strength requirements specified above have been met and subject to the Engineer's approval, forms may be removed at the following minimum times. The Contractor shall assume full responsibility for the strength of all such components from which forms are removed prior to the concrete attaining its full design compressive strength. Shoring may be required at the option of the Engineer beyond these periods.

Ambient Temperature (°F.) During Concrete Placement

	Over 95°	70°-95°	60°-70°	50°-60°	Below 50°
Walls	5 days	2 days	2 days	3 days	Do not remove until directed by Engineer (7 days minimum)
Columns	7 days	2 days	3 days	4 days	
Beam Soffits	10 days	7 days	7 days	7 days	
Elevated Slabs	12 days	7 days	7 days	7 days	

C. When, in the opinion of the Engineer, conditions of the work or weather justify, forms may be required to remain in place for longer periods of time.

D. An accurate record shall be maintained by the Contractor of the dates of concrete placings and the exact location thereof and the dates of removal of forms. These records shall be available for inspection at all times at the site, and two copies shall be furnished the Engineer upon completion of the concrete work.

3.09 RESHORING

A. When reshoring is permitted or required the operations shall be planned in advance and subjected to approval by the Engineer.

B. Reshores shall be placed after stripping operations are complete but in no case later than the end of the working day on which stripping occurs.

C. Reshoring for the purpose of early form removal shall be performed so that at no time will large areas of new construction be required to support their own weight. While reshoring is under way, no construction or live loads shall be permitted on the new construction. Reshores shall be tightened to carry their required loads but they shall not be overtightened

so that the new construction is overstressed. Reshores shall remain in place until the concrete has reached its specified 28-day strength, unless otherwise specified.

D. For floors supporting shores under newly placed concrete, the original supporting shores shall remain in place or reshores shall be placed. The shoring or reshoring system shall have a capacity sufficient to resist the anticipated loads and in all cases shall have a capacity equal to at least one-half of the capacity of the shoring system above. Reshores shall be located directly under a reshore position above unless other locations are permitted.

E. In multi-story buildings, reshoring shall extend over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads so the design superimposed loads of the floors supporting shores are not exceeded.

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SECTION 03200

REINFORCING STEEL

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. Provide all concrete reinforcing including all cutting, bending, fastening and any special work necessary to hold the reinforcing steel in place and protect it from injury and corrosion in accordance with the requirements of this section.

B. Provide deformed reinforcing bars to be grouted into reinforced concrete masonry walls.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03250 - Concrete Accessories

C. Section 03300 - Cast-in-Place Concrete

D. Section 03400 - Precast Concrete

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. CRSI - Concrete Reinforcing Institute Manual of Standard Practice

3. ACI SP66 - ACI Detailing Manual

4. ACI 315 - Details and Detailing of Concrete Reinforcing

5. ACI 318 - Building Code Requirements for Structural Concrete

6. ICC-ES AC193 Acceptance Criteria for Expansion and Screw Anchors (Concrete)

7. WRI - Manual of Standard Practice for Welded Wire Fabric

8. ASTM A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcing

9. ASTM A 1064 - Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

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1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Detailed placing and shop fabricating drawings, prepared in accordance with ACI 315 and ACI Detailing Manual - (SP66), shall be furnished for all concrete reinforcing. These drawings shall be made to such a scale as to clearly show joint locations, openings, and the arrangement, spacing and splicing of the bars.

2. Mill test certificates - 3 copies of each.

3. Description of the reinforcing steel manufacturer's marking pattern.

4. Requests to relocate any bars that cause interferences or that cause placing tolerances to be violated.

5. Proposed supports for each type of reinforcing.

6. Request to use splices not shown on the Drawings.

7. Request to use mechanical couplers along with manufacturer's literature on mechanical couplers with instructions for installation, and certified test reports on the couplers' capacity.

8. Request for placement of column dowels without the use of templates.

9. Request and procedure to field bend or straighten partially embedded reinforcing.

10. International Code Council–Evaluation Services Report (ICC-ES ESR) for dowel adhesives.

11. Certification that all installers of dowel adhesive are certified as Adhesive Anchor Installers in accordance with the ACI-CRSI Anchor Installer Certification Program.

12 Adhesive dowel testing plan.

1.05 QUALITY ASSURANCE

A. If requested by the Engineer, the Contractor shall provide samples from each load of reinforcing steel delivered in a quantity adequate for testing. Costs of initial tests will be paid by the Owner. Costs of additional tests due to material failing initial tests shall be paid by the Contractor.

B. Provide a list of names of all installers who are trained by the Manufacturer’s Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information.

C. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards for all installers who will be installing adhesive anchors in the horizontal to vertically overhead orientation.

D. Special inspections for adhesive dowels shall be conducted in accordance with the manufacturer's instructions and Specification Section 01450. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

PART 2 -- PRODUCTS

2.01 REINFORCING STEEL

A. Bar reinforcing shall conform to the requirements of ASTM A 615 for Grade 60 Billet Steel reinforcing. All reinforcing steel shall be from domestic mills and shall have the manufacturer's mill marking rolled into the bar which shall indicate the producer, size, type and grade. All reinforcing bars shall be deformed bars. Smooth reinforcing bars shall not be used unless specifically called for on Drawings.

B. Welded wire fabric reinforcing shall conform to the requirements of ASTM A 1064 and the details shown on the Drawings.

C. A certified copy of the mill test on each load of reinforcing steel delivered showing physical and chemical analysis shall be provided, prior to shipment. The Engineer reserves the right to require the Contractor to obtain separate test results from an independent testing laboratory in the event of any questionable steel. When such tests are necessary because of failure to comply with this Specification, such as improper identification, the cost of such tests shall be borne by the Contractor.

D. Field welding of reinforcing steel will not be allowed.

E. Use of coiled reinforcing steel will not be allowed.

2.02 ACCESSORIES

A. Accessories shall include all necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers and other devices to position reinforcing during concrete placement. Wire bar supports shall be plastic protected (CRSI Class 1).

B. Concrete blocks (dobies), used to support and position bottom reinforcing steel, shall have the same or higher compressive strength as specified for the concrete in which it is located.

2.03 MECHANICAL COUPLERS

A. Mechanical couplers shall develop a tensile strength which exceeds 100 percent of the ultimate tensile strength and 125 percent of the yield strength of the reinforcing bars being spliced. The reinforcing steel and coupler used shall be compatible for obtaining the required strength of the connection.

B. Where the type of coupler used is composed of more than one component, all components required for a complete splice shall be supplied.

C. Hot forged sleeve type couplers shall not be used. Acceptable mechanical couplers are Dayton Superior Dowel Bar Splicer System by Dayton Superior, Dayton, Ohio, or approved equal. Mechanical couplers shall only be used where shown on the Drawings or where specifically approved by the Engineer.

D. Where the threaded rebar to be inserted into the coupler reduces the diameter of the bar, the threaded rebar piece shall be provided by the coupler manufacturer.

2.04 DOWEL ADHESIVE SYSTEM

A. Where shown on the Drawings, reinforcing bars anchored into hardened concrete with a dowel adhesive system shall use a two-component adhesive mix which shall be injected with a static mixing nozzle following manufacturer's instructions.

B. All holes shall be drilled in accordance with the manufacturer's instructions except that core drilled holes shall not be permitted unless specifically allowed by the Engineer. Cored holes, if allowed by the manufacturer and approved by the Engineer, shall be roughened in accordance with manufacturer's requirements.

C. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with manufacturer's instructions prior to installation of adhesive and reinforcing bar.

D. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer.

E. Injection of adhesive into the hole shall be performed in a manner to minimize the formation of air pockets in accordance with the manufacturer's instructions.

F. Embedment Depth:

1. The embedment depth of the bar shall be as shown on the Drawings. Although all manufacturers listed below are permitted, the embedment depth shown on the Drawings is based on "Pure 110+" by DeWalt" ESR 3298 issued 7/2016. If the Contractor submits one of the other named dowel adhesives from the list below, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.

2. Where the embedment depth is not shown on the Drawings, the embedment depth shall be determined to provide the minimum allowable bond strength equal to the tensile strength of the rebar according to the manufacturer's ICC-ES ESR.

3. The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long term temperature of 110 degrees F, and maximum short term temperature of 140 degrees F. In no case shall the embedment depth be less than the minimum, or more than the maximum, embedment depths stated in the manufacturer's ICC-ES ESR.

G. Engineer's approval is required for use of this system in locations other than those shown on the Drawings.

H. The adhesive system shall be IBC compliant for use in both cracked and uncracked concrete in all Seismic Design Categories and shall be "Epcon C6+ Adhesive Anchoring System" as manufactured by ITW Redhead, " HIT-HY 200 Adhesive Anchoring System" as manufactured by Hilti, Inc. “SET-XP Epoxy Adhesive Anchors” as manufactured by Simpson Strong-Tie Co. or “Pure 110+ Epoxy Adhesive Anchor System” by DeWalt. Fast-set epoxy formulations shall not be acceptable. No or equal products will be considered, unless pre-qualified and approved.

I. All individuals installing dowel adhesive system shall be certified as an Adhesive Anchor Installer in accordance with the ACI-CRSI Anchor Installation Certification Program.

PART 3 – EXECUTION

3.01 TEMPERATURE REINFORCING

A. Unless otherwise shown on the Drawings or in the absence of the concrete reinforcing being shown, the minimum cross sectional area of horizontal and vertical concrete reinforcing in walls shall be 0.0033 times the gross concrete area and the minimum cross sectional area of reinforcing perpendicular to the principal reinforcing in slabs shall be 0.0020 times the gross concrete area. Temperature reinforcing shall not be spaced further apart than five times the slab or wall thickness, nor more than 18 inches.

3.02 FABRICATION

A. Reinforcing steel shall be accurately formed to the dimensions and shapes shown on the Drawings and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings.

B. The Contractor shall fabricate reinforcing bars for structures in accordance with the bending diagrams, placing lists and placing Drawings.

C. No fabrication shall commence until approval of Shop Drawings has been obtained. All reinforcing bars shall be shop fabricated unless approved to be bent in the field. Reinforcing bars shall not be straightened or rebent in a manner that will injure the material. Heating of bars will not be permitted.

D. Welded wire fabric with longitudinal wire of W9.5 size or smaller shall be either furnished in flat sheets or in rolls with a core diameter of not less than 10 inches. Welded wire fabric with longitudinal wires larger than W9.5 size shall be furnished in flat sheets only.

3.03 DELIVERY, STORAGE AND HANDLING

A. All reinforcing shall be neatly bundled and tagged for placement when delivered to the job site. Bundles shall be properly identified for coordination with mill test reports.

B. Reinforcing steel shall be stored above ground on platforms or other supports and shall be protected from the weather at all times by suitable covering. It shall be stored in an orderly manner and plainly marked to facilitate identification.

C. Reinforcing steel shall at all times be protected from conditions conducive to corrosion until concrete is placed around it.

D. The surfaces of all reinforcing steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcing shall be reinspected and if necessary recleaned.

3.04 PLACING

A. Reinforcing steel shall be accurately positioned as shown on the Drawings and shall be supported and wired together to prevent displacement, using annealed iron wire ties or suitable clips at intersections. All reinforcing steel shall be supported by concrete, plastic or plastic protected (CRSI Class 1) metal supports, spacers or metal hangers which are strong and rigid enough to prevent any displacement of the reinforcing steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the reinforcing bars without settlement. In no case shall concrete block supports be continuous.

B. The portions of all accessories in contact with the formwork shall be made of plastic or steel coated with a 1/8 inch minimum thickness of plastic which extends at least 1/2 inch from the concrete surface. Plastic shall be gray in color.

C. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage.

D. Reinforcing bars additional to those shown on the Drawings, which may be found necessary or desirable by the Contractor for the purpose of securing reinforcing in position, shall be provided by the Contractor at no additional cost to the Owner.

E. Reinforcing placing, spacing, and protection tolerances shall be within the limits specified in ACI 318 except where in conflict with the Building Code, unless otherwise specified.

F. Reinforcing bars may be moved within one bar diameter as necessary to avoid interference with other concrete reinforcing, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed placing tolerances, the resulting arrangement of bars shall be as acceptable to the Engineer.

G. Welded wire fabric shall be supported on slab bolsters spaced not less than 30 inches on centers, extending continuously across the entire width of the reinforcing mat and supporting the reinforcing mat in the plane shown on the Drawings.

H. Reinforcing shall not be straightened or rebent unless specifically shown on the drawings. Bars with kinks or bends not shown on the Drawings shall not be used. Coiled reinforcement shall not be used.

I. Dowel Adhesive System shall be installed in strict conformance with the manufacturer's recommendations and as required in Article 2.04 above. A representative of the manufacturer must be on site prior to adhesive dowel installation to provide instruction on proper installation procedures for all adhesive dowel installers. Testing of adhesive dowels shall be as indicated below. If the dowels have a hook at the end to be embedded in subsequent work, an approved mechanical coupler shall be provided at a convenient distance from the face of existing concrete to facilitate adhesive dowel testing while maintaining required hook embedment in subsequent work.

J. All adhesive dowel installations in the horizontal or overhead orientation shall be conducted by a certified Adhesive Anchor Installer as certified by ACI/CSRI per ACI 318-11 9.2.2. Current AAI Certificated must be submitted to the Engineer of Record for approval prior to commencement of any adhesive anchor installations.

K. Adhesive Dowel Testing

1. At all locations where adhesive dowels are shown on the Drawings, at least 5 percent of all adhesive dowels installed shall be tested to the value indicated on the Drawings, with a minimum of one tested dowel per group. If no test value is indicated on the Drawings but the installed dowel is under direct tension, the Contractor shall notify the Engineer to verify the required test value.

2. Contractor shall submit a plan and schedule indicating locations of dowels to be tested, load test values and proposed dowel testing procedure (including a diagram of the testing equipment proposed for use) prior to conducting any testing. The testing equipment shall have a minimum of three support points and shall be of sufficient size to locate the edge of supports no closer than two times the anchor embedment depth from the center of the anchor.

3. Where Contract Documents indicate adhesive dowel design is the Contractor's responsibility, the Contractor shall submit a plan and schedule indicating locations of dowels to be tested and load test values, sealed by a Professional Engineer currently registered in the State of South Carolina. The Contractor shall also submit documentation indicating the Contractor's testing procedures have been reviewed and the proposed procedures are acceptable.

4. Adhesive Dowel shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the dowel after loading shall be considered a failure. Dowels exhibiting damage shall be removed and replaced. If more than 5 percent of tested dowels fail, then 100 percent of dowels shall be proof tested.

5. Proof testing of adhesive dowels shall be performed by an independent testing laboratory hired directly by the Contractor. The Contractor shall be responsible for costs of all testing, including additional testing required due to previously failed tests.

3.05 SPLICING

A. Reinforcing bar splices shall only be used at locations shown on the Drawings. When it is necessary to splice reinforcing at points other than where shown, the splice shall be as acceptable to the Engineer.

B. The length of lap for reinforcing bars, unless otherwise shown on the Drawings shall be in accordance with ACI 318 for a class B splice.

C. Laps of welded wire fabric shall be in accordance with ACI 318. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet. Wires shall be staggered and tied in such a manner that they cannot slip.

D. Mechanical splices shall be used only where shown on the drawings or when approved by the Engineer.

E. Couplers which are located at a joint face shall be a type which can be set either flush or recessed from the face as shown on the Drawings. The couplers shall be sealed during concrete placement to completely eliminate concrete or cement paste from entering. After the concrete is placed, couplers intended for future connections shall be plugged and sealed to prevent any contact with water or other corrosive materials. Threaded couplers shall be plugged with plastic plugs which have an O-ring seal.

3.06 INSPECTION

A. The Contractor shall advise the Engineer of his intentions to place concrete and shall allow him adequate time to inspect all reinforcing steel before concrete is placed.

B. The Contractor shall advise the Engineer of his intentions to place grout in masonry walls and shall allow him adequate time to inspect all reinforcing steel before grout is placed.

3.07 CUTTING OF EMBEDDED REBAR

A. The Contractor shall not cut embedded rebar cast into structural concrete without prior approval.

- END OF SECTION -

SECTION 03250

CONCRETE ACCESSORIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor and equipment required to provide all concrete accessories including waterstops, expansion joint material, joint sealants, expansion joint seals, contraction joint inserts, and epoxy bonding agent.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03290 - Joints in Concrete

C. Section 03300 - Cast-in-Place Concrete

D. Section 07900 - Joint Fillers, Sealants, and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1.	ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
2.	ASTM D412	Standard Tests for Rubber Properties in Tension
3.	ASTM D 624	Standard Test method for Rubber Property - Tear Resistance
4.	ASTM D 638	Standard Test Method for Tensile Properties of Plastics
5.	ASTM D1751	Standard Specifications for Preformed Expansion Joint fillers for Concrete Paving and Structural Construction (nonextruding and resilient bituminous types)
6.	ASTM D 1752	Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
7.	ASTM D 1171	Standard Test Method for Ozone Resistance at 500 pphm
8.	ASTM D 471	Standard Test Method for Rubber Properties

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1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Manufacturer's literature on all products specified herein including material certifications.

2. Proposed system for supporting PVC waterstops in position during concrete placement

3. Samples of products if requested by the Engineer.

PART 2 -- PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) WATERSTOPS

A. PVC waterstops for construction joints shall be flat ribbed type, 6 inches wide with a minimum thickness at any point of 3/8 inches.

B. Waterstops for expansion joints shall be ribbed with a center bulb. They shall be 9 inches wide with a minimum thickness at any point of 3/8 inch unless shown or specified otherwise. The center bulb shall have a minimum outside diameter of 1 inch and a minimum inside diameter of 1/2 inch.

C. The waterstops shall be manufactured from virgin polyvinyl chloride plastic compound and shall not contain any scrap or reclaimed material or pigment whatsoever. The properties of the polyvinyl chloride compound used, as well as the physical properties of the waterstops, shall exceed the requirements of the U.S. Army Corps. of Engineers' Specification CRD-C572. The waterstop material shall have an off-white, milky color.

D. The required minimum physical characteristics for this material are:

1. Tensile strength - 1,750 psi (ASTM D-638).

2. Ultimate elongation - not less than 280% (ASTM D-638).

E. No reclaimed PVC shall be used for the manufacturing of the waterstops. The Contractor shall furnish certification that the proposed waterstops meet the above requirements.

F. PVC waterstops shall be as manufactured by BoMetals, Inc., DuraJoint Concrete Accessories, or Sika Greenstreak.

G. All waterstop intersections, both vertical and horizontal, shall be made from factory fabricated corners and transitions. Only straight butt joint splices shall be made in field.

2.02 RETROFIT WATERSTOPS

A. Retrofit waterstops shall be used where specifically shown on Drawings for sealing joints between existing concrete construction and new construction.

B. Retrofit waterstops shall be PVC waterstops fabricated from material as described in Section 2.01 of this Specification.

C. Retrofit waterstop shall be attached to existing concrete surface as shown on Drawings.

D. Use of split waterstop in lieu of specially fabricated retrofit waterstop will not be acceptable.

E. Retrofit Waterstop manufacturer must provide a complete system including all Waterstop, stainless steel anchoring hardware, and epoxy for installation.

F. For construction joints, retrofit waterstop shall be style number 609 by Sika Greenstreak, RF-638 by BoMetals, Inc., Type 18 kit by DuraJoint Concrete Accessories, or approved equal. For expansion joints, retrofit waterstop shall be style number 667 by Sika Greenstreak, RF-912 by BoMetals, Inc., Type 18-9 kit by DuraJoint Concrete Accessories, or approved equal.

2.03 CHEMICAL RESISTANT WATERSTOPS

(NOT USED)

2.04 HYPALON RUBBER WATERSTOPS

A. Hypalon rubber waterstops shall be Sikadur Combiflex by Sika Corporation or approved equal. Minimum width of waterstop material shall be twelve (12) inches unless shown otherwise on Contract Drawings.

2.05 EXPANDING RUBBER WATERSTOP

A. Expanding rubber shall be designed to expand under hydrostatic conditions. Waterstops shall be Adeka Ultra Seal MC-2010MN by Adeka Ultra Seal/OCM, Inc., or Hydrotite CJ-1020-2K by Sika Greenstreak, for concrete thickness greater than nine inches. For thicknesses less than nine inches, Adeka Ultra Seal KBA-1510FF or Hydrotite CJ-1020-2K shall be used.

B. Waterstop shall be a chemically modified natural rubber product with a hydrophilic agent.

C. Waterstop has a stainless steel mesh or coextrusion of non-hydrophilic rubber to direct expansion in the thickness direction and restrict the expansion in the longitudinal direction.

2.06 WATERSTOP ADHESIVE

A. Adhesive between waterstops and existing concrete shall be 20+F Contact Cement by Miracle Adhesives Corporation, Neoprene Adhesive 77-198 by JGF Adhesives, Sikadur 31 Hi-Mod Gel by Sika Corporation, DP-605 NS Urethane Adhesive by 3M Adhesive Systems.

B. Hydrophilic, non-bentonite water swelling elastic sealant shall be used to bond expanding rubber waterstops to rough surfaces. Hydrophilic elastic sealant shall be P-201 by Adeka Ultra Seal/OCM, Inc., Leakmaster LV-1 by Sika Greenstreak, or approved equal.

2.07 JOINT SEALANTS

A. Joint sealants shall comply with Section 07900, Joint Fillers, Sealants, and Caulking.

2.08 EXPANSION JOINT MATERIAL

A. Preformed expansion joint material shall be non-extruding, and shall be of the following types:

1. Type I - Sponge rubber, conforming to ASTM D1752, Type I.

2. Type II - Cork, conforming to ASTM D1752, Type II.

3. Type III - Self-expanding cork, conforming to ASTM D1752, Type III.

4. Type IV - Bituminous fiber, conforming to ASTM Designation D1751.

2.09 EXPANSION JOINT SEAL

A. Expansion Joint Seal System shall consist of a preformed neoprene profile, installed using the same dimensions as the joint gap, bonded with a two-component epoxy adhesive and pressurized during the adhesive cure time.

B. The expansion joint system shall be Hydrozo/Jeene Structural Sealing joint system by Hydrozo/Jeene, Inc.

2.10 CONTRACTION JOINT INSERTS

A. Contraction joint inserts shall be Zip-Cap by Greenstreak Plastic Products, Zip-Joint by BoMetals, Inc. control joint formers.

2.11 EPOXY BONDING AGENT

A. Epoxy bonding agent shall conform to ASTM C881 and shall be Sikadur 32 Hi-Mod, Sika Corporation, Lyndhurst, N.J.; Euco #452 Epoxy System, Euclid Chemical Company, Cleveland, OH, MasterInject 1500 by BASF Master Builder Solutions (BASF).

2.12 EPOXY RESIN BINDER

A. Epoxy resin binder shall conform to the requirements of ASTM C-881, Type III, Grade 3, Class B and C for epoxy resin binder and shall be Sikadur 23, Low-Mod-Gel, manufactured by the Sika Corporation, Lyndhurst, N.J., Flexocrete Gel manufactured by DuraJoint Concrete Accessories or Euco #352 Gel, Euclid Chemical Company, MasterEmaco ADH 327 or 327 RS by BASF Master Builder Solutions.

PART 3 -- EXECUTION

3.01 PVC AND CHEMICAL RESISTANT WATERSTOPS

A. PVC and chemical resistant waterstops shall be provided in all construction and expansion joints in water bearing structures and at other such locations as required by the Drawings.

B. Waterstops shall be carefully positioned so that they are embedded to an equal depth in concrete on both sides of the joint. They shall be kept free from oil, grease, mortar or other foreign matter. To ensure proper placement, all waterstops shall be secured in correct position at 12" on center along the length of the waterstop on each side, prior to placing concrete. Such method of support shall be submitted to the Engineer for review and approval. Grommets or small pre-punched holes as close to the edges as possible will be acceptable for securing waterstops.

C. Splices in PVC waterstops and chemical resistant waterstops shall be made with a thermostatically controlled heating element. Only straight butt joint splices will be allowed in the field. Factory fabricated corners and transitions shall be used at all intersections. Splices shall be made in strict accordance with the manufacturer's recommended instructions and procedures. At least three satisfactory sample splices shall be made on the site. The Engineer may require tests on these splices by an approved laboratory. The splices shall exhibit not less than 80 percent of the strength of the unspliced material.

D. All splices in waterstops will be subject to rigid review for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, discoloration, charring, and other defects which would reduce the potential resistance of the material to water pressure at any point. All defective joints shall be replaced with material which will pass said review and all faulty material shall be removed from the site and disposed of by the Contractor at no additional cost to the Owner.

E. Retrofit waterstops shall be installed as shown on Contract Drawings using approved waterstop adhesive and Type 316 stainless steel batten bars and expansion anchors.

F. Waterstop installation and splicing defects which are unacceptable include, but are not limited to the following:

1. Tensile strength not less than 80 percent of parent material.

2. Overlapped (not spliced) Waterstop.

3. Misalignment of Waterstop geometry at any point greater than 1/16 inch.

4. Visible porosity or charred or burnt material in weld area.

5. Visible signs of splice separation when splice (24 hours or greater) is bent by hand at sharp angle.

3.02 HYPALON RUBBER AND EXPANDING RUBBER WATERSTOPS

A. Waterstops shall be installed only where shown on the Drawings.

B. Waterstops shall be installed in strict accordance with manufacturer's recommendations.

3.03 WATERSTOP ADHESIVE

A. Adhesive shall be applied to both contact surfaces in strict accordance with manufacturer's recommendations.

B. Adhesive shall be used where waterstops are attached to existing concrete surfaces.

3.04 INSTALLATION OF EXPANSION JOINT MATERIAL AND SEALANTS

A. Type I, II, or III shall be used in all expansion joints in structures and concrete pavements unless specifically shown otherwise on the Drawings. Type IV shall be used in sidewalk and curbing and other locations specifically shown on the Drawings.

B. All expansion joints exposed in the finish work, exterior and interior, shall be sealed with the specified joint sealant. Expansion joint material and sealants shall be installed in accordance with manufacturer's recommended procedures and as shown on the Drawings.

C. Expansion joint material that will be exposed after removal of forms shall be cut and trimmed to ensure a neat appearance and shall completely fill the joint except for the space required for the sealant. The material shall be held securely in place and no concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.

D. A bond breaker shall be used between expansion joint material and sealant. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surfaces shall present a clean and even appearance.

E. Type 1 joint sealant shall be used in all expansion and contraction joints in concrete, except where Type 7 or Type 8 is required as stated below, and wherever else specified or shown on the Drawings. It shall be furnished in pour grade or gun grade depending on installation requirements. Primers shall be used as required by the manufacturer. The sealant shall be furnished in colors as directed by the Engineer.

F. Type 8 joint sealant shall be used in all concrete pavements and floors subject to heavy traffic and wherever else specified or shown on the Drawings.

G. Type 7 joint sealant shall be used for all joints in chlorine contact tanks and wherever specified or shown on the Drawings.

3.05 EXPANSION JOINT SEAL

A. The expansion joint seal system shall be installed as shown on the Drawings in strict accordance with the manufacturer's recommendations.

3.06 CONTRACTION JOINT INSERTS

A. For contraction joints in slabs, inserts shall be floated in fresh concrete during finishing.

B. For contraction joints in walls, inserts shall be secured in place prior to casting wall.

C. Inserts shall be installed true to line at the locations of all contraction joints as shown on the Drawings.

D. Inserts shall extend into concrete sufficient depth as indicated on the Drawings or specified in Section 03290, Joints in Concrete.

E. Inserts shall not be removed from concrete until concrete has cured sufficiently to prevent chipping or spalling of joint edges due to inadequate concrete strength.

3.07 EPOXY BONDING AGENT

A. The Contractor shall use an epoxy bonding agent for bonding fresh concrete to existing concrete as shown on the Drawings.

B. Bonding surface shall be clean, sound and free of all dust, laitance, grease, form release agents, curing compounds, and any other foreign particles.

C. Application of bonding agent shall be in strict accordance with manufacturer's recommendations.

D. Fresh concrete shall not be placed against existing concrete if epoxy bonding agent has lost its tackiness.

3.08 EPOXY RESIN BINDER

A. Epoxy resin binder shall be used to seal all existing rebar cut and burned off during demolition operations. Exposed rebar shall be burned back 1/2-inch minimum into existing concrete and the resulting void filled with epoxy resin binder.

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SECTION 03290

JOINTS IN CONCRETE

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. Provide all materials, labor and equipment required for the construction of all joints in concrete specified herein and shown on the Drawings.

B. Types of joints in concrete shall be as follows:

1. Construction Joints - Joints between adjacent concrete placements continuously connected with reinforcement.

2. Expansion Joints - Joints in concrete which allow thermal expansion and contraction of concrete. Reinforcement terminates within concrete on each side of joint.

3. Contraction Joints - Joints formed in concrete to provide a weakened plane in concrete section to control formation of shrinkage cracks.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03250 - Concrete Accessories

C. Section 03300 - Cast-in-Place Concrete

D. Section 07900 - Joint Fillers, Sealants and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ACI 301 - Specifications for Structural Concrete for Buildings

2. ACI 318 - Building Code Requirements for Structural Concrete

3. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures

4. ACI 224.3 – Joints in Concrete Construction

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Layout drawings showing location and type of all joints to be placed in each structure.

2. Details of proposed joints in each structure.

3. For sawcut contraction joints submit documentation indicating the following:

a. Proposed method of sawcutting indicating early entry or conventional sawing.

b. Description of how work is to be performed including equipment to be utilized, size of crew performing the work and curing methods.

c. Description of alternate method in case of time constraint issues or failure of equipment.

PART 2 -- MATERIALS

2.01 MATERIALS

A. All materials required for joint construction shall comply with Section 03250 - Concrete Accessories, and Section 07900 - Joint Fillers, Sealants and Caulking.

PART 3 -- EXECUTION

3.01 CONSTRUCTION JOINTS

A. Construction joints shall be as shown on the Drawings. Otherwise, Contractor shall submit description of the joint and its location to Engineer for approval.

B. Unless noted otherwise on the Drawings, construction joints shall be located near the middle of the spans of slabs, beams, and girders unless a beam intersects a girder at this point. In this case, the joints in the girders shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and the top of footings or floor slabs unless noted otherwise on Drawings. Beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

C. Maximum distance between horizontal joints in slabs and vertical joints in walls shall be 45'-0". For exposed walls with fluid or earth on the opposite side, the spacing between vertical and horizontal joints shall be a maximum of 25’-0”.

D. All corners shall be part of a continuous placement, and should a construction joint be required, the joint shall not be located closer than five feet from a corner.

E. All reinforcing steel and welded wire fabric shall be continued across construction joints. Keys and inclined dowels shall be provided as shown on the Drawings or as directed by the Engineer. Longitudinal keys shall be provided in all joints in walls and between walls and slabs or footings, except as specifically noted otherwise on the Drawings. Size of keys shall be as shown on the Drawings.

F. All joints in water bearing structures shall have a waterstop. All joints below grade in walls or slabs which enclose an accessible area shall have a waterstop.

3.02 EXPANSION JOINTS

A. Size and location of expansion joints shall be as shown on the Drawings.

B. All expansion joints in water-bearing structures shall have a center-bulb type waterstop. All expansion joints below grade in walls or slabs which enclose an accessible area shall have a center-bulb type waterstop. Waterstop shall be as shown on Drawings and specified in Section 03250, Concrete Accessories.

3.03 CONTRACTION JOINTS

A. Location of contraction joints shall be as shown on the Drawings.

B. Contraction joints shall be formed either by sawcutting or with contraction joint inserts as specified in Section 03250, Concrete Accessories. Sawcutting of joints will not be permitted unless specifically approved by the Engineer.

C. If approved by the Engineer, sawcutting of contraction joints in lieu of forming shall conform to the following requirements:

1. Joints shall be sawed as soon as the concrete can support foot traffic without leaving any impression, normally the same day as concrete is placed and in no case longer than 24 hours after concrete is placed.

2. Curing shall be performed using wet curing methods as indicated in Section 03370 – Concrete Curing. Curing mats, fabrics or sheeting materials shall remain in place to the extent possible while cutting of joint is being performed. Curing materials shall only be removed as required and shall be immediately reinstalled once cutting of the joint has been completed.

3. Depth of joint shall be as shown on the drawings or noted in these specifications. At locations where the joint cannot be installed to full depth due to curbs or other stopping points hand tools shall be used to complete joints.

4. Saw cut joints shall meet the requirements of ACI 224.3, Section 2.8, Jointing Practice.

D. Unless noted otherwise on Drawings, depth of contraction joints shall be 1-1/2 inches in reinforced concrete and 1/3 of concrete thickness in unreinforced concrete.

3.04 JOINT PREPARATION

A. No concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.

B. The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed by wire brushing, air or light sand blasting.

C. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surface shall present a clean and even appearance.

D. All joints shall be sealed as shown on the Drawings and specified in Section 03250, Concrete Accessories.

- END OF SECTION -

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Provide all labor, equipment, materials and services necessary for the manufacture, transportation and placement of all plain and reinforced concrete work, as shown on the Drawings or as ordered by the Engineer.

B. The requirements in this section shall apply to the following types of concrete:

1. Class A1 Concrete: Normal weight structural concrete to be used in all structures qualifying as environmental concrete structures that are designed in accordance with ACI 350 including pump stations, tanks, basins, process structures, and any structures containing fluid or process chemicals or other materials used in treatment process.

2. Class A2 Concrete: Normal weight structural concrete in all structures other than structures qualifying as environmental concrete structures as described above, and for all sidewalks and pavement.

3. Class A4 Concrete: Normal weight structural concrete to be used where specifically called for on Contract Drawings or areas where specifically requested by Contractor and approved by Engineer. Class A4 concrete is identical to Class A2 concrete except that coarse aggregate specified in Article 2.05 below shall be Size #8 in accordance with ASTM C33.

4. Class B Concrete: Normal weight structural concrete used for duct bank encasements, catch basins, fence and guard post embedment, concrete fill, and other areas where specifically noted on Contract Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Reinforcing Steel

C. Section 03250 - Concrete Accessories

D. Section 03290 - Joints in Concrete

E. Section 03350 - Concrete Finishes

F. Section 03370 - Concrete Curing

G. Section 03600 - Grout

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1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1.	South Carolina Building Code	
2.	ACI 214	Guide to Evaluation of Strength Test Results of Concrete
3.	ACI 301	Specifications for Structural Concrete
4.	ACI 304	Guide for Measuring, Mixing, Transporting, and Placing Concrete
5.	ACI 305	Guide to Hot Weather Concreting
6.	ACI 306	Guide to Cold Weather Concreting
7.	ACI 309	Guide for Consolidation of Concrete
8.	ACI 318	Building Code Requirements for Structural Concrete and Comentary
9.	ACI 350	Code Requirements for Environmental Engineering Concrete Structures
10.	ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
11.	ASTM C 33	Standard Specification for Concrete Aggregates
12.	ASTM C 39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
13.	ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
14.	ASTM C 88	Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate
15.	ASTM C 94	Standard Specification for Ready-Mixed Concrete
16.	ASTM C 114	Standard Test Method for Chemical Analysis of Hydraulic Cement
17.	ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

18.	ASTM C 138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
19.	ASTM C 143	Standard Test Method for Slump of Hydraulic Cement Concrete
20.	ASTM C 150	Standard Specification for Portland Cement
21.	ASTM C 172	Standard Practice for Sampling Freshly Mixed Concrete
22.	ASTM C 192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
23.	ASTM C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
24.	ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
25.	ASTM C 295	Standard Guide for Petrographic Examination of Aggregates for Concrete
26.	ASTM C 457	Standard Test Method for Microscopical Determination of the Air-Void System in Hardened Concrete
27.	ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
28.	ASTM C 595	Standard Specification for Blended Hydraulic Cements
29.	ASTM C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
30.	ASTM C 989	Standard Specification for Slag Cement for Use in Concrete and Mortars
31.	ASTM C 1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
32.	ASTM C 1260	Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)
33.	ASTM C 1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
34.	ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
35.	ASTM C 1778	Reducing the Risk of Deleterious Alkali – Aggregate Reaction in Concrete

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Sources of all materials and certifications of compliance with specifications for all materials.

2. Certified current (less than 1 year old) chemical analysis of the Portland Cement or Blended Cement to be used.

3. Certified current (less than 1 year old) chemical analysis of fly ash or slag cement to be used.

4. Aggregate test results showing compliance with required standards, i.e., sieve analysis, potential reactivity, aggregate soundness tests, petrographic analysis, mortar bar expansion testing, etc.

5. Manufacturer's data on all admixtures stating compliance with required standards.

6. Concrete mix design for each class of concrete specified herein.

7. Field experience records and/or trial mix data for the proposed concrete mixes for each class of concrete specified herein.

1.05 QUALITY ASSURANCE

A. Tests on materials used in the production of concrete shall be required as specified in PART 2 -- PRODUCTS. These tests shall be performed by an independent testing laboratory approved by the Engineer at no additional cost to the Owner.

B. Trial concrete mixes shall be tested when required in accordance with Article 3.01 at no additional cost to the Owner.

C. Field quality control tests, as specified in Article 3.10, unless otherwise stated, will be performed by a materials testing consultant employed by the Owner. However, the Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. Any individual who samples and tests concrete to determine if the concrete is being produced in accordance with this Specification shall be certified as a Concrete Field Testing Technician, Grade I, in accordance with ACI CP-2. Testing laboratory shall conform to requirements of ASTM C-1077.

PART 2 -- PRODUCTS

2.01 HYDRAULIC CEMENT

A. Portland Cement

1. Portland Cement shall be Type II conforming to ASTM C 150. Type I cement may be used provided either fly ash or slag cement is also included in the mix in accordance with Articles 2.02 or 2.03 respectively.

2. When potentially reactive aggregates as defined in Article 2.05 are to be used in concrete mix, cement shall meet the following requirements:

   a. For concrete mixed with only Portland Cement, the total alkalies in the cement (calculated as the percentage of NA_2O plus 0.658 times the percentage of K_2O) shall not exceed 0.40%.

   b. For concrete mixed with Portland Cement and an appropriate amount of fly ash (Article 2.02) or slag cement (Article 2.03) the total alkalies in the Portland Cement (calculated as the percentage of NA_2O plus 0.658 times the percentage of K_2O) shall not exceed 0.85%.

3. When non-reactive aggregates as defined in Article 2.05 are used in concrete mix, total alkalies in the cement shall not exceed 1.0%.

4. The proposed Portland Cement shall not contain more than 8% tricalcium aluminate and more than 12% tetracalcium aluminoferrite.

B. Blended Cement

1. Blended cements shall be Type IP (Portland Fly Ash Cement) or Type IS (Portland Slag Cement) conforming to ASTM C 595.

2. Type IP cement shall be an interground blend of Portland Cement and fly ash in which the fly ash constituent is between 15% and 25% of the weight of the total blend.

3. Type IS cement shall be an interground blend of Portland Cement and slag cement in which the slag constituent is between 35% and 50% of the weight of the total blend.

4. Fly ash and slag cement used in the production of blended cements shall meet the requirements of Articles 2.02 and 2.03, respectively.

5. When reactive aggregates as defined in Article 2.05 are used in concrete mix, the total alkalies in the Portland Cement (calculated as the percentage of Na_2O plus 0.658 times the percentage of K_2O) shall not exceed 0.85%. The percentage of fly ash or slag cement shall be set to meet provisions of Article 2.05.G.3.

C. Different types of cement shall not be mixed nor shall they be used alternately except when authorized in writing by the Engineer. Different brands of cement or the same brand from different mills may be used alternately. A resubmittal will be required if different cements are proposed during the Project.

D. Cement shall be stored in a suitable weather-tight building so as to prevent deterioration or contamination. Cement which has become caked, partially hydrated, or otherwise damaged will be rejected.

2.02 FLY ASH

A. Fly ash shall meet the requirements of ASTM C 618 for Class F, except that the loss on ignition shall not exceed 4%. Fly ash shall also meet the optional physical requirements for uniformity as shown in Table 3 of ASTM C 618.

B. For fly ash to be used in the production of type IP cement, the Pozzolan Activity Index shall be greater than 75% as specified in Table 3 of ASTM C 595.

C. Where reactive aggregates as defined in Article 2.05 are used in concrete mix, the fly ash constituent shall be between 15% and 25% of the total weight of the combined Portland Cement and fly ash. The percentage of fly ash shall be set to meet the mean mortar bar expansion requirements in provisions of Article 2.05.G.2.

D. For Type A1 concrete as required for use in environmental concrete structures, i.e. process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.

E. Additional fly ash shall not be included in concrete mixed with Type IS or IP cement.

2.03 SLAG CEMENT

A. Slag cement shall meet the requirements of ASTM C 989 including tests for effectiveness of slag in preventing excessive expansion due to alkali-aggregate reactivity as described in Appendix X-3 of ASTM C 989.

B. Where reactive aggregates as defined in Article 2.05 are used in concrete mix, the slag cement constituent shall be between 35% and 40% of the total weight of the combined Portland Cement and slag. The percentage of slag cement shall be set to meet the mean mortar bar expansion requirements in provisions of Article 2.05.G.2.

C. For Type A1 concrete as required for use in environmental concrete structures, i.e. process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.

D. Additional slag cement shall not be included in concrete mixed with type IS or IP cement.

2.04 WATER

A. Water used for mixing concrete shall be clear, potable and free from deleterious substances such as objectionable quantities of silty organic matter, alkali, salts and other impurities.

B. Water shall not contain more than 100 PPM chloride.

C. Water shall not contain more than 500 PPM dissolved solids.

D. Water shall have a pH in the range of 4.5 to 8.5.

E. Water shall meet requirements of ASTM C 1602.

2.05 AGGREGATES

A. All aggregates used in normal weight concrete shall conform to ASTM C 33.

B. Fine Aggregate (Sand) in the various concrete mixes shall consist of natural or manufactured siliceous sand, clean and free from deleterious substances, and graded within the limits of ASTM C 33.

C. Coarse aggregates shall consist of hard, clean, durable gravel, crushed gravel or crushed rock. Coarse aggregate shall be size #57 or #67 as graded within the limits given in ASTM C 33 unless otherwise specified.

D. For Class A4 concrete, coarse aggregate shall be Size #8 in accordance with ASTM C33.

E. Aggregates shall be tested for gradation by sieve analysis tests in conformance with ASTM C 136.

F. Aggregates shall be tested for soundness in accordance with ASTM C 88. The loss resulting after five cycles shall not exceed 10 percent for fine or coarse aggregate when using either magnesium sulfate or sodium sulfate.

G. All aggregates shall be evaluated in accordance with ASTM C 1778 to determine potential reactivity. All aggregates shall be considered reactive unless they meet the requirements below for non-reactive aggregates. Aggregates with a lithology essentially similar to sources in the same region found to be reactive in service shall be considered reactive regardless of the results of the tests above.

1. Non-reactive aggregates shall meet the following requirements:

   A petrographic analysis in accordance with ASTM C295 shall be performed to identify the constituents of the fine and coarse aggregate. Non-reactive aggregates shall meet the following limitations:

   a. Optically strained, microfractured, or microcrystalline quartz, 5.0%, maximum.

   b. Chert or chalcedony, 3.0%, maximum.

   c. Tridymite or cristobalite, 1.0%, maximum.

   d. Opal, 0.5%, maximum.

   e. Natural volcanic glass in volcanic rocks, 3.0%, maximum.

2. Concrete mixed with reactive aggregates shall meet the following requirements:

   a. If aggregates are deemed potentially reactive as per ASTM C-1778 and fly ash or slag cement is included in proposed concrete mix design, proposed concrete mix including proposed aggregates shall be evaluated by ASTM C-1567. Mean mortar bar expansions at 16 days shall be less than 0.08%.

Tests shall be made using exact proportion of all materials proposed for use on the job in design mix submitted.

b. If aggregates are deemed potentially reactive as per ASTM C-1778 and a straight cement mix without fly ash or slag cement is proposed for concrete mix design, aggregates shall be evaluated by ASTM C-1260. Mean mortar bar expansions at 16 days shall be less than 0.08%.

H. Contractor shall submit a new trial mix to the Engineer for approval whenever a different aggregate or gradation is proposed.

2.06 STRUCTURAL MACRO FIBERS

(NOT USED)

2.07 ADMIXTURES

A. Air entraining agent shall be added to all concrete unless noted otherwise. The agent shall consist of a neutralized vinsol resin solution or a purified hydrocarbon with a cement catalyst which will provide entrained air in the concrete in accordance with ASTM C 260. The admixture proposed shall be selected in advance so that adequate samples may be obtained and the required tests made. Air content of concrete, when placed, shall be within the ranges given in the concrete mix design.

B. The following admixtures are required or used for water reduction, slump increase, and/or adjustment of initial set. Admixtures permitted shall confirm to the requirements of ASTM C 494. Admixtures shall be non-toxic after 30 days and shall be compatible with and made by the same manufacturer as the air-entraining admixtures.

1. Water reducing admixture shall conform to ASTM C 494, Type A and shall contain no more than 0.05% chloride ions. Acceptable products are “Eucon Series” by the Euclid Chemical Company, “Master Pozzolith Series” by BASF, and “Plastocrete Series” by Sika Corporation.

2. High range water reducer shall be sulfonated polymer conforming to ASTM C 494, Type F or G. The high range water reducer shall be added to the concrete at either the batch plant or at the job site and may be used in conjunction with a water reducing admixture. The high range water reducer shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician. A standby system shall be provided and tested prior to each day’s operation of the job site system. Concrete shall be mixed at mixing speed for a minimum of 100 mixer revolutions after the addition of the high range water reducer. Acceptable products are “Eucon 37” or Plastol 5000 by the Euclid Chemical Company, “Master Rheobuild 1000 or Master Glenium Series” by BASF, and “Daracem 100 or Advaflow Series” by W.R. Grace.

3. A non-chloride, non-corrosive accelerating admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C 494, Type C or E, and shall not contain more chloride ions than are present in municipal drinking water. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year’s duration) using an

acceptable accelerated corrosion test method such as that using electrical potential measures. Acceptable products are “Accelguard 80/90 or NCA” by the Euclid Chemical Company and “Daraset” by W.R. Grace.

4. A water reducing retarding admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C494, Type D and shall not contain more than 0.05% chloride ions. Acceptable products are “Eucon NR or Eucon Retarder 100” by the Euclid Chemical Company, “Pozzolith Retarder” by BASF, and “Plastiment” by Sika Corporation.

C. Admixtures containing calcium chloride, thiocyanate or more than 0.05 percent chloride ions are not permitted. The addition of admixtures to prevent freezing is not permitted.

D. The Contractor shall submit manufacturer's data including the chloride ion content of each admixture and certification from the admixture manufacturer that all admixtures utilized in the design mix are compatible with one another and properly proportioned prior to mix design review.

2.08 CONCRETE MIX DESIGN

A. The proportions of cement, aggregates, admixtures and water used in the concrete mixes shall be based on the results of field experience or preferably laboratory trial mixes in conformance with Section 5.3. "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318 and ACI 350. When trial mixes are used they shall also conform to Article 3.01 of this Section of the Specifications. If field experience records are used, concrete strength results shall be from concrete mixed with all of the ingredients proposed for use on job used in similar proportions to mix proposed for use on job. Contractor shall submit verification confirming this stipulation has been followed. Field experience records and/or trial mix data used as the basis for the proposed concrete mix design shall be submitted to the Engineer along with the proposed mix.

B. Structural concrete shall conform to the following requirements. Cementitious materials refer to the total combined weight of all cement, fly ash, and slag cement contained in the mix.

1. Compressive Strength (28-Day)

a. Concrete Class A1	4,500 psi (minimum)
b. Concrete Class A2, A4	4,000 psi (minimum)
c. Concrete Class B	3,000 psi (minimum)

2. Water/cementitious materials ratio, by weight

	Maximum	Minimum
a. Concrete Class A1	0.42	0.39
b. Concrete Class A2, A4	0.45	0.39
c. Concrete Class B	0.50	0.39

3. Slump range — 4" nominal unless high range water reducing admixture is used.
8” max if high range water reducing admixture is used.

4. Air Content

a.	Class A1, A2, A4	6% ±1.5%
b.	Class B	3% Max (non air-entrained)

PART 3 -- EXECUTION

3.01 TRIAL MIXES

A. When trial mixes are used to confirm the quality of a proposed concrete mix in accordance with Section 5.3, "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318 and ACI 350, an independent qualified testing laboratory designated and retained by the Contractor shall test a trial batch of each of the preliminary concrete mixes submitted by the Contractor. The trial batches shall be prepared using the aggregates, cement and admixtures proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain enough samples to satisfy requirements stated below. Tests on individual materials stated in PART 2 -- PRODUCTS should already be performed before any trial mix is done. The cost of laboratory trial batch tests for each specified concrete mix will be borne by the Contractor and the Contractor shall furnish and deliver the materials to the testing laboratory at no cost to the Owner.

B. The independent testing laboratory shall prepare a minimum of fifteen (15) standard test cylinders in accordance with ASTM C 31 in addition to conducting slump (ASTM C 143), air content (C 231) and unit weight (C 138) tests. Compressive strength test on the cylinders shall subsequently be performed by the same laboratory in accordance with ASTM C 39 as follows: Test 3 cylinders at age 7 days; test 3 cylinders at age 21 days; test 3 cylinders at age 28 days and test 3 cylinders at 56 days. The cylinders shall be carefully identified as "Trial Mix, Contract No. , Product ." If the average 28-day compressive strength of the trial mix is less than that specified, or if any single cylinder falls below the required strength by more than 500 psi, the mix shall be corrected, another trial batch prepared, test cylinders taken, and new tests performed as before. Any such additional trial batch testing required shall be performed at no additional cost to the Owner. Adjustments to the mix shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor.

3.02 PRODUCTION OF CONCRETE

A. All concrete shall be machine mixed. Hand mixing of concrete will not be permitted. The Contractor may supply concrete from a ready mix plant or from a site mixed plant. In selecting the source for concrete production the Contractor shall carefully consider its capability for providing quality concrete at a rate commensurate with the requirements of the placements so that well bonded, homogenous concrete, free of cold joints, is assured.

B. Ready-Mixed Concrete

1. At the Contractor's option, ready-mixed concrete may be used meeting the requirements for materials, batching, mixing, transporting, and placing as specified herein and in accordance with ASTM C 94.

2. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter

shall be of the resettable, recording type, and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.

3. Each batch of concrete shall be mixed in a truck mixer for not less than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.

4. Truck mixers and their operation shall be such that the concrete throughout the mixed batch, as discharged, is within acceptable limits of uniformity with respect to consistency, mix and grading. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than one inch when the specified slump is 3 inches or less, or if they differ by more than 2 inches when the specified slump is more than 3 inches, the mixer shall not be used on the work unless the causing condition is corrected and satisfactory performance is verified by additional slump tests. All mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.

5. Ready-mixed concrete shall be delivered to the site for the work and discharge shall be completed before the drum has been revolved 300 revolutions and within the time requirements stated in Article 3.03 of this Section.

6. Each and every concrete delivery shall be accompanied by a delivery ticket containing at least the following information:

    a. Date and truck number
    b. Ticket number
    c. Mix designation of concrete
    d. Cubic yards of concrete
    e. Cement brand, type and weight in pounds
    f. Weight in pounds of fine aggregate (sand)
    g. Weight in pounds of coarse aggregate (stone)
    h. Air entraining agent, brand, and weight in pounds and ounces
    i. Other admixtures, brand, and weight in pounds and ounces
    j. Water, in gallons, stored in attached tank
    k. Water, in gallons, maximum that can be added without exceeding design water/cementitious materials ratio
    l. Water, in gallons, actually used (by truck driver)
    m. Time of loading
    n. Time of delivery to job (by truck driver)

7. Any truck delivering concrete to the job site, which is not accompanied by a delivery ticket showing the above information will be rejected and such truck shall immediately depart from the job site.

8. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the Engineer.

C. Site Mixed Concrete

1. Scales for weighing concrete ingredients shall be accurate when in use within ±0.4 percent of their total capacities. Standard test weights shall be available to permit checking scale accuracy.

2. Operation of batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances:

a.	Cement, fly ash, or slag cement	± 1 percent
b.	Water	± 1 percent
c.	Aggregates	± 2 percent
d.	Admixtures	± 3 percent

3. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.

4. The concrete shall be mixed in a batch mixer capable of thoroughly combining the aggregates, cement, and water into a uniform mass within the specified mixing time, and of discharging the concrete without harmful segregation. The mixer shall bear a manufacturer's rating plate indicating the rate capacity and the recommended revolutions per minute and shall be operated in accordance therewith.

5. Mixers with a rate capacity of 1 cu.yd. or larger shall conform to the requirements of the Plant Mixer Manufacturers' Division of the Concrete Plant Manufacturers' Bureau.

6. Except as provided below, batches of 1 cu. yd. or less shall be mixed for not less than 1 minute. The mixing time shall be increased 15 seconds for each cubic yard or fraction thereof of additional capacity.

7. Shorter mixing time may be permitted provided performance tests made in accordance with of ASTM C 94 indicate that the time is sufficient to produce uniform concrete.

8. Controls shall be provided to insure that the batch cannot be discharged until the required mixing time has elapsed. At least three-quarters of the required mixing time shall take place after the last of the mixing water has been added.

9. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixer blades shall be replaced when they have lost 10 percent of their original height.

10. Air-entraining admixtures and other chemical admixtures shall be charged into the mixer as solutions and shall be measured by means of an approved mechanical dispensing device. The liquid shall be considered a part of the mixing water. Admixtures that cannot be added in solution may be weighed or may be measured by volume if so recommended by the manufacturer.

11. If two or more admixtures are used in the concrete, they shall be added separately to avoid possible interaction that might interfere with the efficiency of either admixture or adversely affect the concrete.

12. Addition of retarding admixtures shall be completed within 1 minute after addition of water to the cement has been completed, or prior to the beginning of the last three-quarters of the required mixing, whichever occurs first. Retarding admixtures shall not be used unless approved by the Engineer.

13. Concrete shall be mixed only in quantities for immediate use and within the time and mixing requirements of ASTM C 94.

3.03 CONCRETE PLACEMENT

A. No concrete shall be placed prior to approval of the concrete mix design. Concrete placement shall conform to the recommendations of ACI 304.

B. Prior to concrete placement, all reinforcement shall be securely and properly fastened in its correct position. Formwork shall be clean, oiled and form ties at construction joints shall be retightened. All bucks, sleeves, castings, hangers, pipe, conduits, bolts, anchors, wire, and any other fixtures required to be embedded therein shall be in place. Forms for openings to be left in the concrete shall be in place and anchored by the Contractor. All loose debris in bottoms of forms or in keyways shall be removed and all debris, water, snow, ice and foreign matter shall be removed from the space to be occupied by the concrete. The Contractor shall notify the Engineer in advance of placement, allowing sufficient time for a concurrent inspection and for any corrective measures which are subsequently required.

C. On horizontal joints where concrete is to be placed on hardened concrete, flowing concrete containing a high range water reducing admixture or cement grout shall be placed with a slump not less than 8 inches for the initial placement at the base of the wall. Concrete or cement grout shall meet all strength and service requirements specified herein for applicable class of concrete. This concrete shall be worked well into the irregularities of the hard surface.

D. All concrete shall be placed during the daylight hours except with the consent of the Engineer. If special permission is obtained to carry on work during the night, adequate lighting must be provided.

E. When concrete arrives at the project with slump below that suitable for placing, as indicated by the Specifications, water may be added to bring the concrete within the specified slump range provided that the design water-cementitious materials ratio is not exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing required. Water may be added only to full trucks. On-site tempering shall not relieve the Contractor from furnishing a concrete mix that meets all specified requirements.

F. Concrete shall be conveyed as rapidly as practicable to the point of deposit by methods which prevent the separation or loss of the ingredients. It shall be so deposited that rehandling will be unnecessary. Discharge of the concrete to its point of deposit shall be completed within 90 minutes after the addition of the cement to the aggregates. In hot weather, or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed the requirements stated in Article 3.09 of this Section.

G. Where concrete is conveyed to position by chutes, a practically continuous flow in the chute shall be maintained. The angle and discharge arrangement of the chute shall be such as to prevent segregation of the concrete ingredients. The delivery end of the chute shall be as close as possible to the point of deposit and in no case shall the free pour from the delivery end of the chute exceed five feet, unless approved otherwise.

H. Special care must be exercised to prevent splashing of forms or reinforcement with concrete, and any such splashes or accumulations of hardened or partially hardened concrete on the forms or reinforcement above the general level of the concrete already in place must be removed before the work proceeds. Concrete shall be placed in all forms in such way as to prevent any segregation.

I. Placing of concrete shall be so regulated that the pressure caused by the wet concrete shall not exceed that used in the design of the forms.

J. All concrete for walls shall be placed through openings in the form spaced at frequent intervals or through tremies (heavy duct canvas, rubber, etc.), equipped with suitable hopper heads. Tremies shall be of variable lengths so the free fall shall not exceed five (5) feet and a sufficient number shall be placed in the form to ensure the concrete is kept level at all times.

K. When placing concrete which is to be exposed, sufficient illumination shall be provided in the interior of the forms so the concrete, at places of deposit, is visible from deck and runways.

L. Concrete shall be placed so as to thoroughly embed all reinforcement, inserts, and fixtures.

M. When forms are removed, surfaces shall be even and dense, free from aggregate pockets or honeycomb. To achieve this, concrete shall be consolidated using mechanical vibration, supplemented by forking and spading by hand in the corners and angle of forms and along form surfaces while the concrete is plastic under the vibratory action. Consolidation shall conform to ACI 309.

N. Mechanical vibration shall be applied directly to the concrete, unless otherwise approved by the Engineer. The bottom of vibrators used on floor slabs must not be permitted to ride the form supporting the slab. Vibration shall be applied at the point of deposit and in the area of freshly placed concrete by a vertical penetration of the vibrator. Vibrators shall not be used to move concrete laterally within the forms.

O. The intensity of vibration shall be sufficient to cause settlement of the concrete into place and to produce monolithic joining with the preceding layer. It shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures with a vibrator transmitting not less than 7,500 impulses per minute. Since the duration of vibration per square foot of surface is dependent on the frequency (impulses per minute), size of vibrator, and slump of concrete, the length of time must therefore be determined in the field. Vibration, however, shall not be continued in any one location to the extent that pools of grout are formed.

P. Care shall be taken to prevent cold joints when placing concrete in any portion of the work. The concrete placing rate shall be such as to ensure that each layer is placed while the previous layer is soft or plastic, so that the two layers can be made monolithic by penetration of the vibrators. Maximum thickness of concrete layers shall be 18 inches. The surface of the concrete shall be level whenever a run of concrete is stopped.

Q. To prevent featheredges, construction joints located at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface, so the angle between such inclined surface and the exposed concrete surface will be not less than 50°.

R. In placing unformed concrete on slopes, the concrete shall be placed ahead of a non-vibrated slip-form screed extending approximately 2-1/2 feet back from its leading edge. The method of placement shall provide a uniform finished surface with the deviation from the straight line less than 1/8 inch in any concrete placement. Concrete ahead of the slip-form screed shall be consolidated by internal vibrators so as to ensure complete filling under the slip-form. Prior to placement of concrete on sloped walls or slabs, the Contractor shall submit a plan specifically detailing methods and sequence of placements, proposed concrete screed equipment, location of construction joints and waterstops, and/or any proposed deviations from the aforementioned to the Engineer for review and approval.

S. Concrete shall not be placed during rains sufficiently heavy or prolonged to wash mortar from coarse aggregate on the forward slopes of the placement. Once placement of concrete has commenced in a block, placement shall not be interrupted by diverting the placing equipment to other uses.

3.04 PLACING FLOOR SLABS ON GRADE

A. The subgrade for slabs on ground shall be well drained and of adequate and uniform loadbearing nature. The in-place density of the subgrade soils shall be at least the minimum required by the specifications. No foundation, slab, or pavement concrete shall be placed until the depth and character of the foundation soils have been inspected and approved by the materials testing consultant.

B. The subgrade shall be free of frost before concrete placing begins. If the temperature inside a building where concrete is to be placed is below freezing it shall be raised and maintained above 50° long enough to remove all frost from the subgrade.

C. The subgrade shall be moist at the time of concreting. If necessary, it shall be dampened with water in advance of concreting, but there shall be no free water standing on the subgrade nor any muddy or soft spots when the concrete is placed.

D. Thirty-pound felt paper shall be provided between edges of slab-on-grade and vertical and horizontal concrete surfaces, unless otherwise indicated on the Drawings.

E. Contraction joints shall be provided in slabs-on-grade at locations indicated on the Drawings. Contraction joints shall be installed as per Section 03290 - Joints in Concrete.

F. Floor slabs shall be screeded level or pitched to drain as indicated on the Drawings. Finishes shall conform with requirements of Section 03350 - Concrete Finishes. Interior floor slabs shall be placed with non-air-entrained concrete (Class A3) if a steel troweled or hardened finish is required.

3.05 PLACING CONCRETE UNDERWATER (CLASS A5 CONCRETE)

A. Placing concrete underwater (tremie concrete) will be permitted only when shown on the Drawings. Concrete deposited under water shall be carefully placed in a compacted mass in final position by means of a tremie, a closed bottom dump bucket or other approved method. Care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. Underwater formwork shall be watertight. The consistency of the concrete shall be regulated to prevent segregation of materials. The method of depositing concrete shall be regulated such that the concrete enters the mass of the previously placed concrete from within, displacing water with a minimum disturbance to the surface of the concrete.

B. Tremie shall consist of a tube having a diameter of not less than 10 inches and constructed in sections having flanged couplings fitted with gaskets. The tremie shall be supported to permit free movement of the discharge and over the entire top surface of the work and shall permit rapid lowering when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow shall then be stopped by lowering the tremie. The flow shall be continuous until the placement has been completed.

3.06 PLACING CONCRETE UNDER PRESSURE

A. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall have the capacity for the operation. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. To obtain the least line resistance, the layout of the pipeline system shall contain a minimum number of bends with no change in pipe size. If two sizes of pipe must be used, the smaller diameter should be used at the pump end and the larger at the discharge end. When pumping is completed, the concrete remaining in the pipelines, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

B. Priming of the concrete pumping equipment shall be with cement grout only. Use of specialty mix pump primers or pumping aids will not be allowed.

C. No aluminum parts shall be in contact with the concrete during the entire placing of concrete under pressure at any time.

D. Prior to placing concrete under pressure, the Contractor shall submit the concrete mix design together with test results from a materials testing consultant proving the proposed mix meets all requirements. In addition, an actual pumping test under field conditions is required prior to acceptance of the mix. This test requires a duplication of anticipated site conditions from beginning to end. The batching and truck mixing shall be the same as will be used; the same pump and operator shall be present and the pipe and pipe layouts will reflect the maximum height and distance contemplated. All submissions shall be subject to approval by the Engineer.

E. If the pumped concrete does not produce satisfactory end results, the Contractor shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.

F. The pumping equipment must have two cylinders and be designed to operate with one cylinder only in case the other one is not functioning. In lieu of this requirement, the Contractor may have a standby pump on the site during pumping.

G. The minimum diameter of the hose (conduits) shall be four inches.

H. Pumping equipment and hoses (conduits) that are not functioning properly shall be replaced.

I. Concrete samples for quality control in accordance with Article 3.10 will be taken at the placement (discharge) end of the line.

3.07 ORDER OF PLACING CONCRETE

A. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints shown on the Drawings and maximum lengths as indicated on Drawings. Where required on the Drawings and wherever else practical, the placing of such units shall be done in a strip pattern in accordance with ACI 302.1. A minimum of 72 hours shall pass prior to placing concrete directly adjacent to previously placed concrete.

3.08 CONCRETE WORK IN COLD WEATHER

A. Cold weather concreting procedures shall conform to the requirements of ACI 306.

B. The Engineer may prohibit the placing of concrete at any time when air temperature is 40°F. or lower. If concrete work is permitted, the concrete shall have a minimum temperature, as placed, of 55°F. for placements less than 12" thick, 50°F. for placements 12" to 36" thick, and 45°F. for placements greater than 36" thick. The temperature of the concrete as placed shall not exceed the aforementioned minimum values by more than 20°F, unless otherwise approved by the Engineer.

C. All aggregate and water shall be preheated. Precautions shall be taken to avoid the possibility of flash set when aggregate or water are heated to a temperature in excess of 100°F. in order to meet concrete temperature requirements. The addition of admixtures to the concrete to prevent freezing is not permitted. All reinforcement, forms, and concrete accessories with which the concrete is to come in contact shall be defrosted by an approved method. No concrete shall be placed on frozen ground.

3.09 CONCRETE WORK IN HOT WEATHER

A. Hot weather concreting procedures shall conform to the requirements of ACI 305.

B. When air temperatures exceed 85°F., or when extremely dry conditions exist even at lower temperatures, particularly if accompanied by high winds, the Contractor and his concrete supplier shall exercise special and precautionary measures in preparing, delivering, placing, finishing, curing and protecting the concrete mix. The Contractor shall consult with the Engineer regarding such measures prior to each day's placing operation and the Engineer reserves the right to modify the proposed measures consistent with the requirements of this Section of the Specifications. All necessary materials and equipment shall be on hand an in position prior to each placing operation.

C. Preparatory work at the job site shall include thorough wetting of all forms, reinforcing steel and, in the case of slab pours on ground or subgrade, spraying the ground surface on the preceding evening and again just prior to placing. No standing puddles of water shall be permitted in those areas which are to receive the concrete.

D. The temperature of the concrete mix when placed shall not exceed 90°F.

E. Temperature of mixing water and aggregates shall be carefully controlled and monitored at the supplier's plant, with haul distance to the job site being taken into account. Stockpiled aggregates shall, if necessary, be shaded from the sun and sprinkled intermittently with water. If ice is used in the mixing water for cooling purposes, it must be entirely melted prior to addition of the water to the dry mix.

F. Delivery schedules shall be carefully planned in advance so that concrete is placed as soon as practical after it is properly mixed. For hot weather concrete work (air temperature greater than 85°F), discharge of the concrete to its point of deposit shall be completed within 60 minutes from the time the concrete is batched.

G. The Contractor shall arrange for an ample work force to be on hand to accomplish transporting, vibrating, finishing, and covering of the fresh concrete as rapidly as possible.

3.10 QUALITY CONTROL

A. Field Testing of Concrete

1. The Contractor shall coordinate with the Engineer's project representative the on-site scheduling of the materials testing consultant personnel as required for concrete testing.

2. Concrete for testing shall be supplied by the Contractor at no additional cost to the Owner, and the Contractor shall provide assistance to the materials testing consultant in obtaining samples. The Contractor shall dispose of and clean up all excess material.

B. Consistency

1. The consistency of the concrete will be checked by the materials testing consultant by standard slump cone tests. The Contractor shall make any necessary adjustments in the mix as the Engineer and/or the materials testing consultant may direct and shall upon written order suspend all placing operations in the event the consistency does not meet the intent of the specifications. No payment shall be made for any delays, material or labor costs due to such eventualities.

2. Slump tests shall be made in accordance with ASTM C 143. Slump tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.

3. Concrete with a specified nominal slump shall be placed having a slump within 1" (higher or lower) of the specified slump. Concrete with a specified maximum slump shall be placed having a slump less than the specified slump.

C. Unit Weight

1. Samples of freshly mixed concrete shall be tested for unit weight by the materials testing consultant in accordance with ASTM C 138.

2. Unit weight tests will be performed as deemed necessary by the Engineer and each time compressive strength samples are taken.

D. Air Content

1. Samples of freshly mixed concrete will be tested for entrained air content by the materials testing consultant in accordance with ASTM C 231.

2. Air content tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.

3. In the event test results are outside the limits specified, additional testing shall occur. Admixture quantity adjustments shall be made immediately upon discovery of incorrect air entrainment.

E. Compressive Strength

1. Samples of freshly mixed concrete will be taken by the materials testing consultant and tested for compressive strength in accordance with ASTM C 172, C 31 and C 39, except as modified herein.

2. In general, one sampling shall be taken for each placement in excess of five (5) cubic yards, with a minimum of one (1) sampling for each day of concrete placement operations, or for each one hundred (100) cubic yards of concrete, or for each 5,000 square feet of surface area for slabs or walls, whichever is greater.

3. Each sampling shall consist of at least five (5) 6x12 cylinders or (8) 4x8 cylinders. Each cylinder shall be identified by a tag, which shall be hooked or wired to the side of the container. The materials testing consultant will fill out the required information on the tag, and the Contractor shall satisfy himself that such information shown is correct.

4. The Contractor shall be required to furnish labor to the Owner for assisting in preparing test cylinders for testing. The Contractor shall provide approved curing boxes for storage of cylinders on site. The insulated curing box shall be of sufficient size and strength to contain all the specimens made in any four consecutive working days and to protect the specimens from falling over, being jarred or otherwise disturbed during the period of initial curing. The box shall be erected, furnished and maintained by the Contractor. Such box shall be equipped to provide the moisture and to regulate the temperature necessary to maintain the proper curing conditions required by ASTM C 31. Such box shall be located in an area free from vibration such as pile driving and traffic of all kinds and such that all specimen are shielded from direct sunlight and/or radiant heating sources. No concrete requiring inspection shall be delivered to the site until such storage curing box has been provided. Specimens shall remain undisturbed in the curing box until ready for delivery to the testing laboratory but not less than sixteen hours.

5. The Contractor shall be responsible for maintaining the temperatures of the curing box during the initial curing of test specimens with the temperature preserved between 60°F and 80°F as measured by a maximum-minimum thermometer. The Contractor shall maintain a written record of curing box temperatures for each day curing box contains test specimens. Temperature shall be recorded a minimum of three times a day with one recording at the start of the work day and one recording at the end of the work day.

6. When transported, the cylinders shall not be thrown, dropped, allowed to roll, or be damaged in any way.

7. Compression tests shall be performed in accordance with ASTM C 39. For 6x12 cylinders, two test cylinders will be tested at seven days and two at 28 days. For 4x8 cylinders, three test cylinders will be tested at seven days, three at 28 days. The remaining cylinders will be held to verify test results, if needed.

F. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 214, ACI 318, and ACI 350.

2. The strength level of concrete will be considered satisfactory if all of the following conditions are satisfied.

a. Every arithmetic average of any three consecutive strength tests equals or exceeds the minimum specified 28-day compressive strength for the mix (see Article 2.08).

b. No individual compressive strength test results falls below the minimum specified strength by more than 500 psi.

3. In the event any of the conditions listed above are not met, the mix proportions shall be corrected for the next concrete placing operation.

4. In the event that condition 2B is not met, additional tests in accordance with Article 3.10, paragraph H shall be performed.

5. When a ratio between 7-day and 28-day strengths has been established by these tests, the 7-day strengths shall subsequently be taken as a preliminary indication of the 28-day strengths. Should the 7-day test strength from any sampling be more than 10% below the established minimum strength, the Contractor shall:

a. Immediately provide additional periods of curing in the affected area from which the deficient test cylinders were taken.

b. Maintain or add temporary structural support as required.

c. Correct the mix for the next concrete placement operation, if required to remedy the situation.

6. All concrete which fails to meet the ACI requirements and these specifications is subject to removal and replacement at no additional cost to the Owner.

G. When non-compliant concrete is identified, test reports shall be sent immediately to the Engineer for review.

H. Additional Tests

1. When ordered by the Engineer, additional tests on in-place concrete shall be provided and paid for by the Contractor.

2. In the event the 28-day test cylinders fail to meet the minimum strength requirements as outlined in Article 3.10, paragraph F, the Contractor shall have concrete core specimens obtained and tested from the affected area immediately.

a. Three cores shall be taken for each sample in which the strength requirements were not met.

b. The drilled cores shall be obtained and tested in conformance with ASTM C 42. The tests shall be conducted by a materials testing consultant approved by the Engineer.

c. The location from which each core is taken shall be approved by the Engineer. Each core specimen shall be located, when possible, so its axis is

perpendicular to the concrete surface and not near formed joints or obvious edges of a unit of deposit.

d. The core specimens shall be taken, if possible, so no reinforcing steel is within the confines of the core.

e. The diameter of core specimens should be at least 3 times the maximum nominal size of the course aggregate used in the concrete, but must be at least 2-inches in diameter.

f. The length of specimen, when capped, shall be at least twice the diameter of the specimen.

g. The core specimens shall be taken to the laboratory and when transported, shall not be thrown, dropped, allowed to roll, or damaged in any way.

h. Two (2) copies of test results shall be mailed directly to the Engineer. The concrete in question will be considered acceptable if the average compressive strength of a minimum of three test core specimens taken from a given area equal or exceed 85% of the specified 28-day strength and if the lowest core strength is greater than 75% of the specified 28-day strength.

3. In the event that concrete placed by the Contractor is suspected of not having proper air content, the Contractor shall engage a materials testing consultant approved by the Engineer, to obtain and test samples for air content in accordance with ASTM Specification C 457.

3.11 CARE AND REPAIR OF CONCRETE

A. The Contractor shall protect all concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance by the Owner. Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface. Care shall be exercised to avoid jarring forms or placing any strain on the ends of projecting reinforcing bars. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at no additional cost to the Owner.

B. Areas of honeycomb shall be chipped back to sound concrete and repaired as directed.

C. Concrete formwork blowouts or unacceptable deviations in tolerances for formed surfaces due to improperly constructed or misaligned formwork shall be repaired as directed. Bulging or protruding areas, which result from slipping or deflecting forms shall be ground flush or chipped out and redressed as directed.

D. Areas of concrete in which cracking, spalling, or other signs of deterioration develop prior to final acceptance shall be removed and replaced, or repaired as directed. This stipulation includes concrete that has experienced cracking due to drying or thermal shrinkage of the concrete. Structural cracks shall be repaired using an approved epoxy injection system. Non-structural cracks shall be repaired using an approved hydrophilic resin pressure injected grout system, unless other means of repair are deemed necessary and approved. All repair work shall be performed at no additional cost to the Owner.

E. Concrete which fails to meet the strength requirements as outlined in Article 3.10, paragraph F, will be analyzed as to its adequacy based upon loading conditions, resultant stresses and exposure conditions for the particular area of concrete in question. If the concrete in question is found unacceptable based upon this analysis, that portion of the structure shall be strengthened or replaced by the Contractor at no additional cost to the Owner. The method of strengthening or extent of replacement shall be as directed by the Engineer.

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SECTION 03350

CONCRETE FINISHES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide finishes of all concrete surfaces specified herein and shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 – Concrete Formwork

B. Section 03300 – Cast-in-Place Concrete

C. Section 03600 – Grout

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ACI 301 – Specifications for Structural Concrete for Buildings

2. ACI 318 – Building Code Requirements for Structural Concrete

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300 – Submittals.

1. Manufacturer's literature on all products specified herein.

PART 2 -- PRODUCTS

2.01 CONCRETE FLOOR SEALER

A. Floor sealer shall be Diamond Clear VOX or Super Diamond Clear VOX by the Euclid Chemical Company, MasterKure CC 300 SB by BASF Master Builder Solutions.

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2.02 CONCRETE LIQUID DENSIFIER AND SEALANT

A. Concrete liquid densifier and sealant shall be a high performance, deeply penetrating concrete densifier and sealant. Product shall be odorless, colorless, VOC-compliant, non-yellowing siliconate based solution designed to harden, dustproof and protect concrete floors subjected to heavy vehicular traffic and to resist black rubber tire marks on concrete surfaces. The product must contain a minimum solids content of 20% of which 50% is siliconate. Acceptable products are Diamond Hard by the Euclid Chemical Company, Seal Hard by L&M Construction Chemicals and MasterKure HD 210 WB by BASF Master Builder Solutions.

2.03 NON-METALLIC FLOOR HARDENER

A. The specified non-metallic mineral aggregate hardener shall be formulated, processed, and packaged under stringent quality control at the manufacturer's owned and controlled factory. The hardener shall be a factory-blended mixture of specifically processed graded mineral aggregate, selected Portland cement, and necessary plasticizing agents. Acceptable products shall be "Surflex" by the Euclid Chemical Company, "Harcol" by Sonneborn, "Maximent" by BASF, and "Mastercon" by BASF.

2.04 NON-OXIDIZING HEAVY DUTY METALLIC FLOOR HARDENER

A. Non-oxidizing heavy duty metallic floor hardener shall be formulated, processed, and packaged under stringent quality control at the manufacturer's owned and controlled factory. The hardener shall be a mixture of specifically processed non-rusting aggregate, selected Portland cement, and necessary plasticizing agents. Product shall be "Diamond-Plate" by the Euclid Chemical Company, or Masterplate by BASF Construction Chemicals.

2.05 NON-SLIP FLOORING ADDITIVE

A. Non-slip flooring additives for slip resistant floors shall be non-metallic. Non-slip flooring additives shall be Frictex NS by BASF Construction Chemicals, A-H Alox by Anti-Hydro, or Euco Grip by the Euclid Chemical Company.

PART 3 -- EXECUTION

3.01 FINISHES ON FORMED CONCRETE SURFACES

A. After removal of forms, the finishes described below shall be applied in accordance with Article 3.05 - Concrete Finish Schedule. Unless the finish schedule specifies otherwise, all surfaces shall receive at least a Type I finish. The Engineer shall be the sole judge of acceptability of all concrete finish work.

1. Type I - Rough: All fins, burrs, offsets, marks and all other projections left by the forms shall be removed. Projections, depressions, etc. below finished grade required to be removed will only be those greater than ¼-inch. All holes left by removal of ends of ties, and all other holes, depressions, bugholes, air/blow holes or voids shall be filled solid with cement grout after first being thoroughly wetted and then struck off flush. The only holes below grade to be filled will be tie holes and any other holes larger than ¼-inch in any dimension. Honeycombs shall be chipped back to solid concrete and repaired as directed by the Engineer. All holes shall be filled with tools, such as sponge floats and trowels, that will permit packing the hole solidly with cement grout. Cement grout shall consist of one part cement to three parts sand, epoxy bonding agent (for tie holes only) and the amount of mixing water shall be as little as consistent with the requirements of handling and placing. Color of cement grout shall match the adjacent wall surface.

2. Type II - Grout Cleaned: Where this finish is required, it shall be applied after completion of Type I finish. After the concrete has been predampened, a slurry consisting of one part cement (including an appropriate quantity of white cement in order to produce a color matching the surrounding concrete) and 1-1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Mix proportions shall be submitted to the Engineer after a sample of the work is established and accepted. Any surplus shall be removed by scraping and then rubbing with clean burlap.

3. Type III - Smooth Rubbed: Where this finish is required, it shall be applied after the completion of the Type II finish. No rubbing shall be done before the concrete is thoroughly hardened and the mortar used for patching is firmly set. A smooth, uniform surface shall be obtained by wetting the surface and rubbing it with a carborundum stone to eliminate irregularities. Unless the nature of the irregularities requires it, the general surface of the concrete shall not be cut into. Corners and edges shall be slightly rounded by the use of the carborundum stone. Brush finishing or painting with grout or neat cement will not be permitted. A 100 square foot example shall be established at the beginning of the project to establish acceptability.

3.02 SLAB AND FLOOR FINISHES

A. The finishes described below shall be applied to floors, slabs, flow channels and top of walls in accordance with Article 3.05 - Concrete Finish Schedule. The Engineer shall be the sole judge of acceptability of all such finish work.

1. Type "A" - Screeded: This finish shall be obtained by placing screeds at frequent intervals and striking off to the surface elevation required. When a Type "F" finish is subsequently to be applied, the surface of the screeded concrete shall be roughened with a concrete rake to 1/2” minimum deep grooves prior to final set.

2. Type "B" - Wood or Magnesium Floated: This finish shall be obtained after completion of a Type "A" finish by working a previously screeded surface with a wood or magnesium float or until the desired texture is reached. Floating shall begin when the water sheen has disappeared and when the concrete has sufficiently hardened so that a person's foot leaves only a slight imprint. If wet spots occur, water shall be removed with a squeegee. Care shall be taken to prevent the formation of laitance and excess water on the finished surface. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finished surface shall be true, even, and free from blemishes and any other irregularities.

3. Type "C" - Cork Floated: This finish shall be similar to Type "B" but slightly smoother than that obtained with a wood float. It shall be obtained by power or band floating with cork floats.

4. Type "D" - Steel Troweled: This finish shall be obtained after completion of a Type "B" finish. When the concrete has hardened sufficiently to prevent excess fine material from working to the surface, the surface shall be compacted and smoothed with not less than two thorough and complete steel troweling operations. In areas which are to receive a floor covering such as tile, resilient flooring, or carpeting, the applicable Specification Sections and Contract Drawings shall be reviewed for the required finishes and degree of flatness. In areas that are intermittently wet such as pump rooms, only one troweling operation is required to provide some trowel marks for slip resistance. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finish shall be brought to a smooth, dense surface, free from defects and blemishes.

5. Type "E" - Broom or Belt: This finish shall provide the surface with a transverse scored texture by drawing a broom or burlap belt across the surface immediately after completion of a Type "B" finish. All edges shall be edged with an 1/8-inch tool as directed by the Engineer.

6. Type "F" - Swept in Grout Topping: This finish shall be applied after a completion of a Type "A" finish. The concrete surface shall be properly cleaned, washed, and coated with a mixture of water and Portland Cement. Cement grout in accordance with Section 03600 shall then be plowed and swept into neat conformance with the blades or arms of the apparatus by turning or rotating the previously positioned mechanical equipment. Special attention shall be paid to true grades, shapes and tolerances as specified by the manufacturer of the equipment. Before beginning this finish, the Contractor shall notify the Engineer and the equipment manufacturer of the details of the operation and obtain approval and recommendations.

7. Type “G” Hardened Finish: This finish shall be applied after completion of a Type “B” or Type “C” finish and prior to application of a Type “D” finish. Hardeners shall be applied in strict accordance with the manufacturer’s requirements. Hardeners shall be applied using a mechanical spreader. The hardener shall be applied in two shakes with the first shake comprising 2/3 of the total amount. Type “D” finish shall be applied following completion of application of the hardener.

    a. Non-metallic floor hardener shall be applied where specifically required on the Contract Drawings at the rate of 1.0 pounds/ft.^{2}.

    b. Non-oxidizing heavy duty metallic floor hardener shall be applied at the loading docks and where specifically required on the Contract Drawings or specified herein at the rate of 1.5 pounds/ft.^{2}.

8. Type "H" - Non-Slip Finish: This finish shall be provided by applying a non-slip flooring additive concurrently with the application of a Type "D" finish and/or installation of floor sealants. Application procedure shall be in accordance with manufacturer's instructions. Finish shall be applied where specifically required on the Contract Drawings or specified herein.

9. Type "J" - Raked Finish: This finish shall be provided by raking the surface as soon as the condition of the concrete permits by making depressions of ±1/4 inch.

3.03 CONCRETE SEALERS

A. Concrete sealers shall be applied where specifically required on the Contract Drawings or specified herein.

B. Sealers shall be applied after installation of all equipment, piping, etc. and after completion of any other related construction activities. Application of sealers shall be in strict accordance with manufacturer’s requirements.

C. Sealers shall be applied to all floor slabs not painted and not intended to be immersed.

D. Floor slabs subjected to vehicular traffic shall be sealed with the concrete liquid densifier and sealer.

E. All other floor slabs to receive sealer shall be sealed with concrete floor sealer.

3.04 FINISHES ON EQUIPMENT PADS

A. Formed surfaces of equipment pads shall receive a Type III finish.

B. Top surfaces of equipment pads, except those surfaces subsequently required to receive grout and support equipment bases, shall receive a Type "D" finish, unless otherwise noted. Surfaces which will later receive grout shall, before the concrete takes its final set, be made rough by removing the sand and cement that accumulates on the top to the extent that the aggregate will be exposed with irregular indentations in the surface up to 1/2 inch deep.

3.05 CONCRETE FINISH SCHEDULE

Item	Type of Finish
Inner face of walls of tanks, flow channels, wet wells, perimeter walls, and miscellaneous concrete structures:	II
Exterior concrete walls below grade	I
Exterior exposed concrete walls, ceilings, beams, manholes, hand holes, miscellaneous structures and columns (including top of wall) to one foot below grade. All other exposed concrete surfaces not specified elsewhere	II
Floors of process equipment tanks or basins, wetwells, flow channels and slabs to receive roofing material or waterproof membranes	B
All interior finish floors of buildings and structures	D
Exterior concrete sidewalks, steps, ramps, decks, slabs on grade and landings exposed to weather	E
Floors of process equipment tanks indicated on Drawings to receive grout topping	F
Precast concrete form panels, hollow core planks, double tees	J

- END OF SECTION -

SECTION 03370

CONCRETE CURING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Protect all freshly deposited concrete from premature drying and from the weather elements. The concrete shall be maintained with minimal moisture loss at a relatively constant temperature for a period of time necessary for the hydration of the cement and proper hardening of the concrete in accordance with the requirements specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 – Concrete Formwork

B. Section 03300 – Cast-In-Place Concrete

C. Section 03350 – Concrete Finishes

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ACI 301 – Specifications for Structural Concrete for Buildings

2. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete

3. ACI 305 – Hot Weather Concreting

4. ACI 306 – Cold Weather Concreting

5. ACI 308 – Standard Practice for Curing Concrete

6. ASTM C171 – Standard Specifications for Sheet Materials for Curing Concrete

7. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

8. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

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1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Proposed procedures for protection of concrete under wet weather placement conditions.

2. Proposed normal procedures for protection and curing of concrete.

3. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.

4. Proposed method of measuring concrete surface temperature changes.

5. Manufacturer's literature and material certification for proposed curing compounds.

PART 2 -- PRODUCTS

2.01 LIQUID MEMBRANE-FORMING CURING COMPOUND

A. Clear curing and sealing compound shall be a clear styrene acrylate type complying with ASTM C 1315, Type 1, Class A with a minimum solids content of 30%. Moisture loss shall not be greater than 0.40 kg/m^2 when applied at 300 sq.ft./gal. Manufacturer's certification is required. Acceptable products are Super Diamond Clear VOX by the Euclid Chemical Company, MasteKure CC 300 SB by BASF Master Builder Solutions, and Cure & Seal 30 Plus by Symons Corporation.

B. Where specifically approved by Engineer, on slabs to receive subsequent applied finishes, compound shall conform to ASTM C 309. Acceptable products are "Kurez DR VOX" or "Kurez W VOX" by the Euclid Chemical Company. Install in strict accordance with manufacturer's requirements.

2.02 EVAPORATION REDUCER

A. Evaporation reducer shall be BASF, "MasterKure ER 50", or Euclid Chemical "Euco-Bar".

PART 3 -- EXECUTION

3.01 PROTECTION AND CURING

A. All freshly placed concrete shall be protected from the elements, flowing water and from defacement of any nature during construction operations.

B. As soon as the concrete has been placed and horizontal top surfaces have received their required finish, provision shall be made for maintaining the concrete in a moist condition for at least a 5-day period thereafter except for high early strength concrete, for which the period shall be at least the first three days after placement. Horizontal surfaces shall be kept covered, and intermittent, localized drying will not be permitted.

C. Walls that will be exposed on one side with either fluid or earth backfill on the opposite side shall be continuously wet cured for a minimum of five days. Use of a curing compound will not be acceptable for applications of this type.

D. The Contractor shall use one of the following methods to insure that the concrete remains in a moist condition for the minimum period stated above.

1. Ponding or continuous fogging or sprinkling.

2. Application of mats or fabric kept continuously wet.

3. Continuous application of steam (under 150°F).

4. Application of sheet materials conforming to ASTM C171.

5. If approved by the Engineer, application of a curing compound in accordance with Article 3.04.

E. The Contractor shall keep absorbent wood forms wet until they are removed. After form removal, the concrete shall be cured by one of the methods in paragraph D.

F. Any of the curing procedures used in Paragraph 3.01-D may be replaced by one of the other curing procedures listed in Paragraph 3.01-D after the concrete is one-day old. However, the concrete surface shall not be permitted to become dry at any time.

3.02 CURING CONCRETE UNDER COLD WEATHER CONDITIONS

A. Suitable means shall be provided for a minimum of 72 hours after placing concrete to maintain it at or above the minimum as placed temperatures specified in Section 03300, Cast-In-Place Concrete, for concrete work in cold weather. During the 72-hour period, the concrete surface shall not be exposed to air more than 20°F above the minimum as placed temperatures.

B. Stripping time for forms and supports shall be increased as necessary to allow for retardation in concrete strength caused by colder temperatures. This retardation is magnified when using concrete made with blended cements or containing fly ash or ground granulated blast furnace slag. Therefore, curing times and stripping times shall be further increased as necessary when using these types of concrete.

C. The methods of protecting the concrete shall be approved by the Engineer and shall be such as will prevent local drying. Equipment and materials approved for this purpose shall be on the site in sufficient quantity before the work begins. The Contractor shall assist the Engineer by providing holes in the forms and the concrete in which thermometers can be placed to determine the adequacy of heating and protection. All such thermometers shall be furnished by the Contractor in quantity and type which the Engineer directs.

D. Curing procedures during cold weather conditions shall conform to the requirements of ACI 306.

3.03 CURING CONCRETE UNDER HOT WEATHER CONDITIONS

A. When air temperatures exceed 85°F, the Contractor shall take extra care in placing and finishing techniques to avoid formation of cold joints and plastic shrinkage cracking. If ordered by the Engineer, temporary sun shades and/or windbreakers shall be erected to guard against such developments, including generous use of wet burlap coverings and fog sprays to prevent drying out of the exposed concrete surfaces.

B. Immediately after screeding, horizontal surfaces shall receive an application of evaporation reducer. Apply in accordance with manufacturer's instructions. Final finish work shall begin as soon as the mix has stiffened sufficiently to support the workmen.

C. Curing and protection of the concrete shall begin immediately after completion of the finishing operation. Continuous moist-curing consisting of method 1 or 2 listed in paragraph 3.01D is mandatory for at least the first 24 hours. Method 2 may be used only if the finished surface is not marred or blemished during contact with the coverings.

D. At the end of the initial 24-hour period, curing and protection of the concrete shall continue for at least six (6) additional days using one of the methods listed in paragraph 3.01D.

E. Curing procedures during hot weather conditions shall conform to the requirements of ACI 305.

3.04 USE OF CURING COMPOUND

A. Curing compound shall be used only where specifically approved by the Engineer. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of five days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.

B. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time period, and the subsequent appearance of the concrete surface shall not be affected.

C. The compound shall be applied in accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. Maximum coverage for the curing and sealing compound shall be 300 square feet per gallon for trowel finishes and 200 square feet per gallon for floated or broom surfaces. Maximum coverage for compounds placed where subsequent finishes will be applied shall be 200 square feet per gallon. For rough surfaces, apply in two directions at right angles to each other.

3.05 EARLY TERMINATION OF CURING

A. Moisture retention measures may be terminated earlier than the specified times only when at least one of the following conditions is met:

1. The strength of the concrete reaches 85 percent of the specified 28-day compressive strength in laboratory-cured cylinders representative of the concrete in place, and the temperature of the in-place concrete has been constantly maintained at 50 degrees Fahrenheit or higher.

2. The strength of concrete reaches the specified 28-day compressive strength as determined by accepted nondestructive methods or laboratory-cured cylinder test results.

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SECTION 03400

PRECAST CONCRETE

PART 1 -- GENERAL

1.01 REQUIREMENTS

A. The Contractor shall construct all precast concrete items as required in the Contract Documents, including all appurtenances necessary to make a complete installation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02604 - Utility Structures

B. Section 03200 - Reinforcing Steel

C. Section 05830 - Bearing Devices

D. Section 03300 - Cast-in-Place Concrete

E. Section 03350 - Concrete Finishes

F. Section 03370 - Concrete Curing

G. Section 03600 - Grout

H. Section 05010 - Metal Materials

I. Section 05035 - Galvanizing

J. Section 05050 - Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the end of the Bid.

1. South Carolina Building Code

2. ACI 318-Building Code Requirements for Structural Concrete

3. PCI Standard MNL-116 - Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products

4. PCI Design Handbook

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1.04 SUBMITTALS

A. The Contractor shall submit the following for review in accordance with Section 01300, Submittals.

1. Shop drawings for all precast concrete items showing all dimensions, locations, and type of lifting inserts, and details of reinforcement and joints.

2. A list of the design criteria used by the manufacturer for all manufactured, precast items.

3. Design calculations, showing at least the design loads and stresses on the item, shall be submitted. Calculations shall be signed and sealed by a Professional Engineer registered in the State of South Carolina.

4. Certified reports for all lifting inserts, indicating allowable design loads.

5. Information on lifting and erection procedures.

1.05 QUALITY ASSURANCE

A. All manufactured precast concrete units shall be produced by an experienced manufacturer regularly engaged in the production of such items. All manufactured precast concrete and site-cast units shall be free of defects, spalls, and cracks. Care shall be taken in the mixing of materials, casting, curing and shipping to avoid any of the above. The Engineer may elect to examine the units at the casting yard or upon arrival of the same at the site. The Engineer shall have the option of rejecting any or all of the precast work if it does not meet with the requirements specified herein or on the Drawings. All rejected work shall be replaced at no additional cost to the Owner.

B. Manufacturer Qualifications

The precast concrete manufacturing plant shall be certified by the Prestressed Concrete Institute, Plant Certification Program, prior to the start of production. Certification is only required for plants providing prestressed structural members such as hollow core planks, double-T members, etc.

C. Plant production and engineering must be under direct supervision and control of an Engineer who possesses a minimum of five years experience in precast concrete work.

PART 2 -- PRODUCTS

2.01 CONCRETE

A. Concrete materials including portland cement, aggregates, water, and admixtures shall conform to Section 03300, Cast-in-Place Concrete.

B. For prestressed concrete items, minimum compressive strength of concrete at 28 days shall be 5,000 psi unless otherwise specified. Minimum compressive strength of concrete at transfer of prestressing force shall be 3,500 psi unless otherwise specified.

C. For non-prestressed concrete items, minimum compressive strength of concrete at 28 days shall be 4000 psi unless otherwise specified.

2.02 GROUT

A. Grout for joints between panels shall be a cement grout in conformance with Section 03600, Grout.

B. Minimum compressive strength of grout at 7 days shall be 3,000 psi.

2.03 REINFORCING STEEL

A. Reinforcing steel used for precast concrete construction shall conform to Section 03200, Reinforcing Steel.

2.04 PRESTRESSING STRANDS

A. Prestressing strands shall be 7-wire, stress-relieved, high-strength strands Grade 250K or 270K in conformance with Section 03230, Stressing Tendons.

2.05 STEEL INSERTS

A. Steel inserts shall be in accordance with Section 05010, Metal Materials.

B. All steel inserts protruding from or occurring at the surface of precast units shall be galvanized in accordance with Section 05035, Galvanizing.

2.06 WELDING

A. Welding shall conform to Section 05050, Metal Fastening.

2.07 BEARING PADS

A. Neoprene bearing pads shall conform to Section 05830, Bearing Devices and Anchors.

B. Plastic bearing pads shall be multi-monomer plastic strips which are non-leaching and support construction loads with no visible overall expansion, manufactured specifically for the purpose of bearing precast concrete.

PART 3 -- EXECUTION

3.01 FABRICATION AND CASTING

A. All precast members shall be fabricated and cast to the shapes, dimensions and lengths shown on the Drawings and in compliance with PCI MNL-116. Precast members shall be straight, true and free from dimensional distortions, except for camber and tolerances permitted later in this clause. All integral appurtenances, reinforcing, openings, etc., shall be accurately located and secured in position with the form work system. Form materials shall be steel and the systems free from leakage during the casting operation.

B. All cover of reinforcing shall be the same as detailed on the Drawings.

C. Because of the critical nature of the bond development length in prestressed concrete panel construction, if the transfer of stress is by burning of the fully tensioned strands at the ends of the member, each strand shall first be burned at the ends of the bed and then at each end of each member before proceeding to the next strand in the burning pattern.

D. The Contractor shall coordinate the communication of all necessary information concerning openings, sleeves, or inserts to the manufacturer of the precast members.

E. Concrete shall be finished in accordance with Section 03350, Concrete Finishes. Grout all recesses due to cut tendons which will not otherwise be grouted during erection.

F. Curing of precast members shall be in accordance with Section 03370, Concrete Curing. Use of a membrane curing compound will not be allowed.

G. The manufacturer shall provide lifting inserts or other approved means of lifting members.

3.02 HANDLING, TRANSPORTING AND STORING

A. Precast members shall not be transported away from the casting yard until the concrete has reached the minimum required 28 day compressive strength and a period of at least 5 days has elapsed since casting, unless otherwise permitted by the Engineer.

B. No precast member shall be transported from the plant to the job site prior to approval of that member by the plant inspector. This approval will be stamped on the member by the plant inspector.

C. During handling, transporting, and storing, precast concrete members shall be lifted and supported only at the lifting or supporting points as indicated on the shop drawings.

D. All precast members shall be stored on solid, unyielding, storage blocks in a manner to prevent torsion, objectionable bending, and contact with the ground.

E. Precast concrete members shall not be used as storage areas for other materials or equipment.

F. Precast members damaged while being handled or transported will be rejected or shall be repaired in a manner approved by the Engineer.

3.03 ERECTION

A. Erection shall be carried out by the manufacturer or under his supervision using labor, equipment, tools and materials required for proper execution of the work.

B. Contractor shall prepare all bearing surfaces to a true and level line prior to erection. All supports of the precast members shall be accurately located and of required size and bearing materials.

C. Installation of the precast members shall be made by leveling the top surface of the assembled units keeping the units tight and at right angles to the bearing surface.

D. Connections which require welding shall be properly made in accordance with Section 05050, Metal Fastening.

E. Grouting between adjacent precast members and along the edges of the assembled precast members shall be accomplished as indicated on the drawings, care being taken to solidly pack such spaces and to prevent leakage or droppings of grout through the assembled precast members. Any grout which seeps through the precast members shall be removed before it hardens.

F. In no case shall concentrated construction loads, or construction loads exceeding the design loads, be placed on the precast members. In no case shall loads be placed on the precast members prior to the welding operations associated with erection, and prior to placing of topping (if required).

G. No Contractor, Subcontractor or any of his employees shall arbitrarily cut, drill, punch or otherwise tamper with the precast members.

H. Precast members damaged while being erected will be rejected or shall be repaired in a manner approved by the Engineer.

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SECTION 03480

PRECAST CONCRETE SPECIALTIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all materials, labor, equipment, and tools required for the design, fabrication, delivery, and installment of precast concrete manhole vaults and meter box structures in accordance with the Drawings and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03400 - Precast Concrete

1.03 SUBMITTALS

A. The Contractor shall submit samples and/or Shop Drawings and in accordance with Section 01300, Submittals.

B. In addition to items listed in Section 03400, Precast Concrete, Shop Drawings shall include, but not be limited to:

1. Piping and conduit sheets.

2. Complete layout and installation Drawings and schedules with clearly marked dimensions.

1.04 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. Federal Specification No. SS-5-00210

2. ASTM C478 - Specification for Precast Reinforced Concrete Manhole Sections

PART 2 -- PRODUCTS

2.01 PRECAST MANHOLES, VAULTS, AND METER BOXES

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A. Precast concrete manholes shall be furnished with waterstops, sleeves and openings as noted on the Drawings. Box out for wall pipes shall conform accurately to the sizes and elevations of the adjoining pipes. Precast manholes shall be watertight and conform to the requirements of ASTM C-478 with reinforcing steel of ASTM A615, Grade 60 bars and the following modifications there to:

1. Materials shall conform to Section 03400, Precast Concrete.

2. The minimum wall thickness shall be 8 inches.

3. The date and time of manufacturer shall be marked inside each precast sections.

4. No more than two lift holes may be cast or drilled in each section.

5. Dimensions shall be as shown on the Drawings.

6. Vault covers and frames shall comply with Section 05500, Metal Fabrications. The frames and covers shall be provided by the vault manufacturer. Covers shall have lifting handles and shall be bolted with stainless steel bolts complying with Section 05050, Metal Fastening. When leveling bolts are used to set the vault top sections, the Contractor shall ensure that the load on the vault will be transferred through the mortar to the vault, and will not be carried by the leveling bolts.

7. Mechanical details such as piping, electrical, and other details shall be as shown on the Drawings.

B. Joints between manhole riser sections and at base slabs shall be groove type. Joints shall be sealed with two (2) individual self sealing butyl rubber gaskets conforming to Federal Specification No. SS-5-00210. The gasket material shall be Kent Seal.

2.02 PIPE CONNECTIONS

A. The precast reinforced concrete manhole base shall be provided with circular openings at the locations and elevations for the proper connection of all pipes. The pipe connections shall be sealed with either a flexible manhole seal assembly or with mortar.

B. When a flexible manhole seal assembly is used to seal the pipe connection, the seal assembly shall be installed in accordance with the recommendations of the seal assembly manufacturer and shall conform to ASTM C923.

C. Flexible manhole seal assemblies shall permit at least an eight (8) degree deflection from the center line of the opening in any direction while maintaining a watertight connection.

D. The flexible manhole seal assembly shall be manufactured by Interpace Corp (Lock Joint Flexible Manhole Sleeve), National Pollution Control Systems, Inc. (Kor-N-Seal) or Press-Seal Gasket Corp. Manhole seal assemblies produced by other manufacturers will be considered for use by Engineer if submitted by the Contractor. Such manhole seal assemblies shall be acceptable only if the Shop Drawings are approved.

E. Short lengths of sewer pipe shall be installed entering and leaving the precast manhole base. These short lengths of pipe shall have a maximum length of 3'3". A concrete cradle shall be placed under the short length of pipe in accordance with the dimensions shown on the Drawings.

F. The concrete cradle is not necessary when a flexible manhole seal assembly is used.

2.03 MANHOLE LADDERS

A. Manhole ladders shall conform to Section 06610, Glass Fiber and Resin Fabrications.

PART 3 -- EXECUTION

3.01 DESIGN CRITERIA

A. Precast items subjected to vehicular traffic shall be designed for H-20 traffic loading. Other precast items shall be designed for a vertical live load of 300 psf.

B. Walls of precast items shall be designed for a vertical surcharge of 100 psf.

3.02 MANUFACTURED ITEMS

A. Precast concrete manhole sections shall be set so as to be vertical, with sections in true alignment. The joint of the previously set section shall be covered with mortar and preformed joint sealant before the next section is placed. Before the mortar is set, joints shall be pointed, and exterior joints shall be thoroughly tooled so as to be slightly concave with a hard polished surface, free of cracks. Interior joints shall be tooled flush in a similar manner.

B. Precast wall sections shall be of such lengths as will permit the setting of the manhole frame for the required elevation on two or three courses of brick masonry laid around the top of the upper section. Such brick work shall be given a 1-inch mortar coat on the inside and outside.

C. Precast items shall be installed in accordance with the manufacturer's recommendations, unless otherwise required by the Drawings.

3.03 MANHOLE LADDERS

A. The ladder shall be installed so bottom of ladder rests on or in the concrete shelf of the invert fill. The bottom step shall not interfere with piping. Angle brackets shall be spaced a maximum of 6 feet apart, with a minimum to two brackets per ladder section. The anchor bolts shall not be located within 12 inches of any joint in the manhole sections. Ladders shall be installed in conformance with the Drawings.

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SECTION 03600

GROUT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all grout used in concrete work and as bearing surfaces for base plates, in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1.	CRD-C 621	Corps of Engineers Specification for Non-shrink Grout
2.	ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm cube Specimens)
3.	ASTM C 531	Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts and Monolithic Surfacings
4.	ASTM C 579	Test Method for Compressive Strength of Chemical-Resistant Mortars and Monolithic Surfacings
5.	ASTM C 827	Standard Test Method for Early Volume Change of Cementitious Mixtures
6.	ASTM C 144	Standard Specification for Aggregate for Masonry Mortar
7.	ASTM C 1107	Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nonshrink)

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1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Certified test results verifying the compressive strength and shrinkage and expansion requirements specified herein.

2. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of grout used in the work.

1.05 QUALITY ASSURANCE

A. Field Tests

1. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications. The specimens will be made by the Engineer or its representative.

a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days and any additional time period as appropriate.

b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time period as appropriate.

2. The cost of all laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Engineer in obtaining specimens for testing. The Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the specifications. The Contractor shall supply all materials necessary for fabricating the test specimens, at no additional cost to the Owner.

3. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Cement Grout

1. Cement grout shall be composed of Portland Cement and sand in the proportion specified in the Contract Documents and the minimum amount of water necessary to obtain the desired consistency. If no proportion is indicated, cement grout shall consist of one part Portland Cement to three parts sand. Water amount shall be as required to achieve desired consistency without compromising strength requirements. White Portland Cement shall be mixed with the Portland Cement as required to match color of adjacent concrete.

2. The minimum compressive strength at 28 days shall be 4000 psi.

3. For beds thicker than 1-1/2 inch and/or where free passage of grout will not be obstructed by coarse aggregate, 1-1/2 parts of coarse aggregate having a top size of 3/8 inch should be added. This stipulation does not apply for grout being swept in by a mechanism. These applications shall use a plain cement grout without coarse aggregate regardless of bed thickness.

4. Sand shall conform to the requirements of ASTM C144.

B. Non-Shrink Grout

1. Non-shrink grout shall conform to CRD-C 621 and ASTM C 1107, Grade B or C when tested at a max. fluid consistency of 30 seconds per CDC 611/ASTM C939 at temperature extremes of 45°F and 90°F and an extended working time of 15 minutes. Grout shall have a min. 28-day strength of 7,000 psi. Non-shrink grout shall be, "Euco N-S" by the Euclid Chemical Company, "Sikagrout 212" by Sika Corporation, “Conspec 100 Non-Shrink Non-Metallic Grout” by Conspec, “Masterflow 555 Grout” by BASF Master Builder Solutions.

C. Epoxy Grout

1. Epoxy grout shall be "Sikadur 32 Hi-Mod" by Sika Corporation, "Duralcrete LV" by Tamms Industries, or "Euco #452 Series" by Euclid Chemical, “MasterEmaco ADH 1090 RS” by BASF Master Builder Solutions.

2. Epoxy grout shall be modified as required for each particular application with aggregate per manufacturer's instructions.

D. Epoxy Base Plate Grout

1. Epoxy base plate grout shall be “Sikadur 42, Grout-Pak” by Sika Corporation, or “Masterflow 648” by BASF Master Builder Solutions.

2.02 CURING MATERIALS

A. Curing materials shall be as specified in Section 03370, Concrete Curing for cement grout and as recommended by the manufacturer for prepackaged grouts.

PART 3 -- EXECUTION

3.01 GENERAL

A. The different types of grout shall be used for the applications stated below unless noted otherwise in the Contract Documents. Where grout is called for in the Contract Documents which does not fall under any of the applications stated below, non-shrink grout shall be used unless another type is specifically referenced.

1. Cement grout shall be used for grout toppings and for patching of fresh concrete.

2. Non-shrink grout shall be used for grouting beneath base plates of structural metal framing.

3. Epoxy grout shall be used for bonding new concrete to hardened concrete.

4. Epoxy base plate grout shall be used for precision seating of base plates including base plates for all equipment such as engines, mixers, pumps, vibratory and heavy impact machinery, etc.

B. New concrete surfaces to receive cement grout shall be as specified in Section 03350, Concrete Finishes, and shall be cleaned of all dirt, grease and oil-like films. Existing concrete surfaces shall likewise be cleaned of all similar contamination and debris, including chipping or roughening the surface if a laitance or poor concrete is evident. The finish of the grout surface shall match that of the adjacent concrete. Curing and protection of cement grout shall be as specified in Section 03370, Concrete Curing.

C. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.

D. The Contractor, through the manufacturer of a non-shrink grout and epoxy grout, shall provide on-site technical assistance upon request, at no additional cost to the Owner.

3.02 CONSISTENCY

A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable but will not flow.

3.03 MEASUREMENT OF INGREDIENTS

A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurement shall not be allowed.

B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

3.04 GROUT INSTALLATION

A. Grout shall be placed quickly and continuously, shall completely fill the space to be grouted and be thoroughly compacted and free of air pockets. The grout may be poured in place, pressure grouted by gravity, or pumped. The use of pneumatic pressure or dry-packed grouting requires approval of the Engineer. For grouting beneath base plates, grout shall be poured from one side only and thence flow across to the open side to avoid air-entrapment.

- END OF SECTION -

SECTION 05010

METAL MATERIALS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Metal materials not otherwise specified shall conform to the requirements of this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Materials for fasteners are included in Section 05050, Metal Fastening.

B. Requirements for specific products made from the materials specified herein are included in other sections of the Specifications. See the section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. ASTM A36 Standard Specification for Structural Steel

B. ASTM A47 Standard Specification for Malleable Iron Castings

C. ASTM A48 Standard Specification for Gray Iron Castings

D. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

E. ASTM A167 Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

F. ASTM A276 Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes

G. ASTM A307 Standard Specification for Carbon Steel Externally Threaded Standard Fasteners

H. ASTM A446 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) quality

I. ASTM A500 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

J. ASTM A501 Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

K. ASTM A529 Standard Specification for Structural Steel with 42 000 psi (290 Mpa) Minimum Yield Point (1/2 in. (12.7 mm) Maximum Thickness)

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L. ASTM A536 Standard Specification for Ductile Iron Castings

M. ASTM A570 Standard Specification for Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality

N. ASTM A572 Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

O. ASTM A992 Standard Specification for Structural Steel Shapes

P. ASTM A666 Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar for Structural Applications

Q. ASTM A1085 Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)

R. ASTM B26 Standard Specification for Aluminum-Alloy Sand Castings

S. ASTM B85 Standard Specification for Aluminum-Alloy Die Castings

T. ASTM B108 Standard Specification for Aluminum-Alloy Permanent Mold Castings

U. ASTM B138 Standard Specification for Manganese Bronze Rod, Bar, and Shapes

V. ASTM B209 Standard Specification for Aluminum-Alloy Sheet and Plate

W. ASTM B221 Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes

X. ASTM B308 Standard Specification for Aluminum-Alloy Standard Structural Shapes, Rolled or Extruded

Y. ASTM B574 Standard Specification for Nickel-Molybdenum-Chromium Alloy Rod

Z. ASTM F468 Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use

a. ASTM F593 Standard Specification for Stainless Steel Fasteners

1.04 SUBMITTALS

A. Material certifications shall be submitted along with any shop drawings for metal products and fabrications required by other sections of the Specifications.

1.05 QUALITY ASSURANCE

A. Owner may engage the services of a testing agency to test any metal materials for conformance with the material requirements herein. If the material is found to be in conformance with Specifications the cost of testing will be borne by the Owner. If the material does not conform to the Specifications, the cost of testing shall be paid by the Contractor and all materials not in conformance as determined by the Engineer shall be replaced by the Contractor at no additional cost to the Owner. In lieu of replacing materials the Contractor may request further testing to determine conformance, but any such testing shall be paid for by the Contractor regardless of outcome of such testing.

PART 2 -- PRODUCTS

2.01 CARBON AND LOW ALLOY STEEL

A. Material types and ASTM designations shall be as listed below:

1.	Steel W Shapes	A992
2.	Steel HP Shapes	A572 Grade 50
3.	Steel M, S, C,and MC shapes and Angles, Bars, and Plates	A36
4.	Rods	F 1554 Grade 36
5.	Pipe - Structural Use	A53 Grade B
6.	Hollow Structural Sections	A500 Grade C or A1085
7.	Cold-Formed Steel Framing	A 653

2.02 STAINLESS STEEL

A. All stainless steel fabrications exposed to underwater service shall be Type 316. All other stainless steel fabrications shall be Type 304, unless noted otherwise.

B. Material types and ASTM designations are listed below:

1.	Plates and Sheets	ASTM A167 or A666 Grade A
2.	Structural Shapes	ASTM A276
3.	Fasteners (Bolts, etc.)	ASTM F593

2.03 ALUMINUM

A. All aluminum shall be alloy 6061-T6, unless otherwise noted or specified herein.

B. Material types and ASTM designations are listed below:

1.	Structural Shapes	ASTM B308
2.	Castings	ASTM B26, B85, or B108
3.	Extruded Bars	ASTM B221 - Alloy 6061
4.	Extruded Rods, Shapes and Tubes	ASTM B221 - Alloy 6063
5.	Plates	ASTM B209 - Alloy 6061
6.	Sheets	ASTM B221 - Alloy 3003

C. All aluminum structural members shall conform to the requirements of Section 05140, Structural Aluminum.

D. All aluminum shall be provided with mill finish unless otherwise noted.

E. Where bolted connections are indicated, aluminum shall be fastened with stainless steel bolts.

2.04 CAST IRON

A. Material types and ASTM designations are listed below:

1.	Gray	ASTM A48 Class 30B
2.	Malleable	ASTM A47
3.	Ductile	ASTM A536 Grade 60-40-18

2.05 BRONZE

A. Material types and ASTM designations are listed below:

1.	Rods, Bars and Sheets	ASTM B138 - Alloy B Soft

2.06 HASTELLOY

A. All Hastelloy shall be Alloy C-276.

2.07 DISSIMILAR METALS

A. Dielectric isolation shall be installed wherever dissimilar metals are connected according to the following table.

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			●	●	●	●	●	●	●
Galvanized Steel			●	●	●	●	●	●	●
Aluminum	●	●		●	●	●	●	●	●
Cast Iron	●	●	●				●	●	●
Ductile Iron	●	●	●				●	●	●
Mild Steel/ Carbon Steel	●	●	●				●	●	●
Copper	●	●	●	●	●	●			●
Brass	●	●	●	●	●	●			●
Stainless Steel	●	●	●	●	●	●	●	●	

1. "●" signifies dielectric isolation is required between the two materials noted.
2. Consult Engineer for items not listed in table.

PART 3 -- EXECUTION

(NOT USED)

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SECTION 05035

GALVANIZING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Where galvanizing is called for in the Contract Documents, the galvanizing shall be performed in accordance with the provisions of this Section unless otherwise noted.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Further requirements for galvanizing specific items may be included in other Sections of the Specifications. See section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. ASTM A123 - Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip

3. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

4. ASTM A653 - Standard Specification for Steel Sheet, Zinc Coated (Galvanized), or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

4. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

5. ASTM A780 - Standard Practice of Repair of Damaged Hot-Dip Galvanized Coatings

6. ASTM F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Certification that the item(s) are galvanized in accordance with the applicable ASTM standards specified herein. This certification may be included as part of any material certification that may be required by other Sections of the Specifications.

PART 2 -- PRODUCTS

2.01 GALVANIC COATING

A. Material composition of the galvanic coating shall be in accordance with the applicable ASTM standards specified herein.

PART 3 -- EXECUTION

3.01 FABRICATED PRODUCTS

A. Products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strips, 1/8 inch thick and heavier which are to be galvanized shall be galvanized in accordance with ASTM A123. Products shall be fabricated into the largest unit which is practicable to galvanize before the galvanizing is done. Fabrication shall include all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, and welding. Components of bolted or riveted assemblies shall be galvanized separately before assembly. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating. The galvanizer shall be a member of American Galvanizers Association.

B. Components with partial surface finishes shall be commercial blast cleaned prior to pickling.

C. Sampling and testing of each lot shall be performed prior to shipment from the galvanizer's facility per ASTM A123.

3.02 HARDWARE

A. Iron and steel hardware which is to be galvanized shall be galvanized in accordance with ASTM A153 and ASTM F2329.

3.03 ASSEMBLED PRODUCTS

A. Assembled steel products which are to be galvanized shall be galvanized in accordance with ASTM A123. All edges of tightly contacting surfaces shall be completely sealed by welding before galvanizing.

B. Assemblies shall be provided with vent and drain holes as required by the fabricator. Vent and drain hole sizes and locations shall be included in the structural steel shop drawings required in Specification 05120 Structural Steel for approval. All vent and drain holes shall be plugged and finished to be flush with and blend in with the surrounding surface. Where water intrusion can occur, the plug shall be carefully melted into the surrounding zinc coating using an appropriate fluxing agent.

3.04 METAL DECK

A. Unless noted otherwise, metal deck shall be galvanized in accordance with ASTM A653 G60 minimum. In moist environments or as indicated on the Contract Drawings, galvanizing shall meet the requirements of ASTM A653 G90.

B. Galvanized metal deck shall meet the requirements of ASTM A924.

3.05 REPAIR OF GALVANIZING

A. Galvanized surfaces that are abraded or damaged at any time after the application of zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with 2 coats of zinc rich paint meeting the requirements of Federal Specification DOD-P-21035A and shall be thoroughly mixed prior to application. Zinc rich paint shall not be tinted. The total thickness of the 2 coats shall not be less than 6 mils. In lieu of repairing by painting with zinc rich paint, other methods of repairing galvanized surfaces in accordance with ASTM A780 may be used provided the proposed method is acceptable to the Engineer.

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SECTION 05050

METAL FASTENING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all metal welds and fasteners not otherwise specified, in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05061 – Stainless Steel

D. Section 05120 - Structural Steel

E. Section 05140 - Structural Aluminum

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2.	AC 193	Acceptance Criteria for Mechanical Anchors in Concrete Elements
3.	AC 308	Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements
4.	ACI 318	Building Code Requirements for Structural Concrete
5.	ACI 355.2	Qualifications of Post-Installed Mechanical Anchors in Concrete
6.	ACI 355.4	Qualifications of Post-Installed Adhesive Anchors in Concrete
7.	ICC-ES AC193	Acceptance Criteria for Expansion and Screw Anchors (Concrete)

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8.	AISC 348	The 2009 RCSC Specification for Structural Joints
9.	AISC	Code of Standard Practice
10.	AWS D1.1	Structural Welding Code - Steel
11.	AWS D1.2	Structural Welding Code - Aluminum
12.	AWS D1.6	Structural Welding Code – Stainless Steel
13.	Aluminum Association	Specifications for Aluminum Structures
14.	ASTM A572/A572M-94C	Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel Grade 50
15.	ASTM A36	Standard Specification for Carbon Structural Steel
16.	ASTM A325	Standard Specification for High-Strength Bolts for Structural Steel Joints
17.	ASTM A489	Standard Specification for Eyebolts
18.	ASTM A490	Standard Specification for Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints
19.	ASTM A563	Standard Specifications for Carbon and Alloy Steel Nuts
20.	ASTM D1785	Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe
21.	ASTM E488	Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
22.	ASTM F436	Standard Specification for Hardened Steel Washers
23.	ASTM F467	Standard Specification for Nonferrous Nuts for General Use
24.	ASTM F593	Standard Specification for Stainless Steel Bolts; Hex Cap Screws, and Studs
25.	ASTM F594	Standard Specification for Stainless Steel Nuts
26.	ASTM F1554	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Shop Drawings providing the fastener's manufacturer and type and certification of the fastener's material and capacity.

2. Anchor design calculations sealed by a Professional Engineer currently registered in the State of South Carolina. Only required if design not shown on Contract Drawings.

3. A current ICC-ES Evaluation Service Report shall be submitted for all anchors that will be considered for use on this project.

4. Manufacturer’s installation instructions.

5. Copy of valid certification for each person who is to perform field welding.

6. Certified weld inspection reports, when required.

7. Welding procedures.

8. Installer qualifications.

9. Certification of Installer Training.

10. Inspection Reports.

10. Results of Anchor Proof Testing.

1.05 QUALITY ASSURANCE

A. Fasteners not manufactured in the United States shall be tested and certification provided with respect to specified quality and strength standards. Certifications of origin shall be submitted for all U.S. fasteners supplied on the project.

B. Installer Qualifications: All concrete anchors shall be installed by an Installer with at least three years of experience performing similar installations. Concrete adhesive anchor installer shall be certified as an Adhesive Anchor Installer in accordance with ACI-CRSI Adhesive Anchor Installation Certification Program.

C. Installer Training: For concrete adhesive, expansion and screw anchors, conduct a thorough training with the manufacturer or the manufacturer’s representative for the Installer on the project. Training shall consist of a review of the complete installation process to include but not be limited to the following:

1. Hole drilling procedure.

2. Hole preparation and cleaning technique.

3. Adhesive injection technique and dispenser training/maintenance.

4. Concrete adhesive anchor preparation and installation.

5. Proof loading/torquing.

6. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information

7. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards for all installers who will be installing adhesive anchors in the horizontal to vertically overhead orientation.

D. All steel welding shall be performed by welders certified in accordance with AWS D1.1. All aluminum welding shall be performed by welders certified in accordance with AWS D1.2. All stainless steel welding shall be performed by welders certified in accordance with AWS D1.6. Certifications of field welders shall be submitted prior to performing any field welds.

E. Welds and high strength bolts used in connections of structural steel will be visually inspected in accordance with Article 3.04.

F. The Owner may engage an independent testing agency to perform testing of welded connections and to prepare test reports in accordance with AWS. Inadequate welds shall be corrected or redone and retested to the satisfaction of the Engineer and/or an acceptable independent testing laboratory, at no additional cost to the Owner.

G. Provide a welding procedure for each type and thickness of weld. For welds that are not prequalified, include a Performance Qualification Report. The welding procedure shall be given to each welder performing the weld. The welding procedure shall follow the format in Annex E of AWS D1.1 with relevant information presented.

H. Special inspections for concrete adhesive anchors shall be conducted in accordance with the manufacturer's instructions and Specifications Section 01450. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

PART 2 -- PRODUCTS

2.01 ANCHOR RODS (ANCHOR BOLTS)

A. Anchor rods shall conform to ASTM F1554 Grade 36 except where stainless steel or other approved anchor rods are shown on the Drawings. Anchor rods shall have hexagonal heads and shall be supplied with hexagonal nuts meeting the requirements of ASTM A563 Grade A.

B. Where anchor rods are used to anchor galvanized steel or are otherwise specified to be galvanized, anchor rods and nuts shall be hot-dip galvanized in accordance with ASTM F1554.

C. Where pipe sleeves around anchor rods are shown on the Drawings, pipe sleeves shall be cut from Schedule 40 PVC plastic piping meeting the requirements of ASTM D1785.

2.02 HIGH STRENGTH BOLTS

A. High strength bolts and associated nuts and washers shall be in accordance with ASTM A325 or ASTM A490. Bolts, nuts and washers shall meet the requirements of AISC 348 "The 2009 RCSC Specification for Structural Joints".

B. Where high strength bolts are used to connect galvanized steel or are otherwise specified to be galvanized, bolts, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A325.

2.03 STAINLESS STEEL BOLTS

A. Stainless steel bolts shall conform to ASTM F-593. All underwater fasteners, fasteners in confined areas containing fluid, and fasteners in corrosive environments shall be Type 316 stainless steel unless noted otherwise. Fasteners for aluminum and stainless steel members not subject to the above conditions shall be Type 304 stainless steel unless otherwise noted.

B. Stainless steel bolts shall have hexagonal heads with a raised letter or symbol on the bolts indicating the manufacturer and shall be supplied with hexagonal nuts meeting the requirements of ASTM F594. Nuts shall be of the same alloy as the bolts.

2.04 CONCRETE ANCHORS

A. General

1. Where concrete anchors are called for on the Drawings, one of the types listed below shall be used; except, where one of the types listed below is specifically called for on the Drawings, only that type shall be used. The determination of anchors equivalent to those listed below shall be on the basis of test data performed by an approved independent testing laboratory. There are two types used:

a. Expansion anchors shall be mechanical anchors of the wedge, sleeve, drop-in or undercut type.

b. Adhesive anchors shall consist of threaded rods or bolts anchored with an adhesive system into hardened concrete. Adhesive anchors shall be two part injection type using the manufacturer's static mixing nozzle and shall be supplied as an entire system.

c. Concrete screw anchors shall be one-piece, heavy duty screw anchor with a finished hex head

2. Expansion anchors shall not be used to hang items from above or in any other situations where direct tension forces are induced in anchor.

3. Unless otherwise noted, all concrete anchors which are submerged or are used in hanging items or have direct tension induced upon them, or which are subject to vibration from equipment such as pumps and generators, shall be adhesive anchors.

4. Adhesive anchors shall conform to the requirements of ACI 355.4 or alternately to AC 308. Expansion, concrete screw or mechanical anchors shall conform to the requirements of ACI 355.2 or alternately to AC 193. Anchors in Seismic Design Categories C through F shall conform to the International Building Code and ACI 318 Appendix D requirements as applicable, including seismic test requirements.

5. Fire Resistance: All anchors installed within fire resistant construction shall either be enclosed in a fire resistant envelope, be protected by approved fire-resistive materials, be used to resist wind and earthquake loads only, or anchor non-structural elements.

6. Engineer's approval is required for use of concrete anchors in locations other than those shown on the Drawings.

B. Concrete Anchor Design:

An anchor design consists of specifying anchor size, quantity, spacing, edge distance and embedment to resist all applicable loads. Where an anchor design is indicated on the Drawings, it shall be considered an engineered design and anchors shall be installed to the prescribed size, spacing, embedment depth and edge distance. If all parts of an anchor design are provided on the Drawings except embedment depth, the anchors will be considered an engineered design and the Contractor shall provide the embedment depth as indicated in Paragraph B.3 unless otherwise directed by the Engineer. Where an anchor design is not indicated by the Engineer on the Drawings, the Contractor shall provide the anchor design per the requirements listed below.

1. Structural Anchors: All concrete anchors shall be considered structural anchors if they transmit load between structural elements; transmit load between non-structural components that make up a portion of the structure and structural elements; or transmit load between life-safety related attachments and structural elements. Examples of structural concrete anchors include but are not limited to column anchor bolts, anchors supporting non-structural walls, sprinkler piping support anchors, anchors supporting heavy, suspended piping or equipment, anchors supporting barrier rails, etc. For structural anchors, the Contractor shall submit an engineered design with signed and sealed calculations performed by an Engineer currently registered in the State of South Carolina. Structural anchors shall be of a type recommended by the anchor manufacturer for use in cracked concrete and shall be designed by the Contractor in accordance with ACI 318 Appendix D.

2. Non-Structural Anchors: All other concrete anchors may be considered non-structural concrete anchors. The Contractor shall perform an engineered design for non-structural anchors. The Engineer may request the Contractor provide anchor design details for review, but submission of a signed, sealed design is not required. Non-structural anchors shall be designed by the contractor for use in uncracked concrete.

3. Embedment Depth

    a. Minimum anchor embedment shall be as indicated on the Drawings or determined by the Contractor's engineered design. Although all manufacturers listed are permitted, the embedment depth indicated on the Drawings is based on ""Pure 110+ by DeWalt" ESR 3298 issued 7/2017. If the contractor submits one of the other concrete adhesive anchors listed, the Engineer shall evaluate the required embedment and the Contractor shall provide the required embedment depth stipulated by the Engineer specific to the approved dowel adhesive.

    b. Where the embedment depth is not shown on the Drawings, concrete anchors shall be embedded no less than the manufacturer's standard embedment (expansion or mechanical anchors) or to provide a minimum allowable bond strength equal to the allowable yield capacity of the rod according to the manufacturer (adhesive anchors).

    c. The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long term temperature of 110 degrees F, and maximum short term temperature of 140 degrees F. In no case shall the embedment depth be less than the minimum or more than the maximum stated in the manufacturer's literature.

C. Structural Anchors:

1. Mechanical Anchors:

a. Wedge Anchors: Wedge anchors shall be “Kwik Bolt TZ” by Hilti, Inc., “TruBolt +” by ITW Redhead, “Strong-Bolt 2” by Simpson Strong-Tie Co. or “Power-Stud+SD1” or “Power-Stud+ SD-2” by DeWalt.

b. Screw Anchors: Screw anchors shall be “Kwik HUS-EZ” and “KWIK HUS-EZ-I” by Hilti, Inc., “Titen HD” by Simpson Strong-Tie Co., or “Screw-Bolt+” by DeWalt. Bits specifically provided by manufacturer of chosen system shall be used for installation of anchors.

c. Sleeve Anchors: Sleeve anchors shall be “HSL-3 Heavy Duty Sleeve Anchor” by Hilti, Inc. or “Power-Bolt +” by DeWalt.

d. Undercut Anchors: Undercut anchors shall be “HDA Undercut Anchor” by Hilti, Inc., “Torq-Cut Undercut Anchor” by Simpson Strong-Tie Co., “Atomic + Undercut Anchor” by DeWalt

e. Shallow Embedment Internally Threaded Insert (3/4” max embedment): “Mini-Undercut +Anchor” by DeWalt, “HSC-A” by Hilti, Inc. or approved equal.

2. Adhesive Anchors:

a. Adhesive anchors shall be “Epcon C6+ Adhesive Anchoring System” by ITW Redhead, “HIT HY-200 Adhesive Anchoring System” by Hilti, Inc., “SET-XP Epoxy Adhesive Anchors” by Simpson Strong-Tie Co., or “Pure 110+ Epoxy Adhesive Anchor System” by DeWalt.

b. Structural adhesive anchor systems shall be IBC compliant and capable of resisting short term wind and seismic loads (Seismic Design Categories A through F) as well as long term and short term sustained static loads in both cracked and uncracked concrete in all Seismic Design Categories. Structural adhesive anchor systems shall comply with the latest revision of ICC-ES Acceptance Criteria AC308, and shall have a valid ICC-ES report in accordance with the applicable building code. **No or equal products will be considered unless prequalified and approved by the Engineer and Owner.**

D. Non-Structural Anchors: In addition to the acceptable non-structural anchors listed below, all structural anchors listed above may also be used as non-structural anchors.

1. Mechanical Anchors:

   a. Wedge Anchors: Wedge anchors shall be “Kwik Bolt 3” by Hilti, Inc., “Power-Stud+ SD1” by DeWalt, “Wedge-All” by Simpson Strong-Tie Co. or “TruBolt” by ITW Redhead.

   b. Screw Anchors: Screw anchors shall be “Kwik HUS” by Hilti, Inc., “Screw Bolt+” or 316 Stainless Steel Wedge-Bolt” by DeWalt, “Large Diameter Tapcon (LDT) Anchor” by ITW Redhead, or “Titen HD” by Simpson Strong-Tie Co. Bits specifically provided by manufacturer of chosen system shall be used for installation of anchors.

   c. Sleeve Anchors: Sleeve anchors shall be “HSL Heavy Duty Sleeve Anchors” by Hilti, Inc. “Power-Bolt+” by DeWalt “Dynabolt Sleeve Anchor” by ITW Redhead, or “Sleeve-All” by Simpson Strong-Tie Co.

   d. Drop-In Anchors: Drop-in anchors shall be “Drop-In” by Simpson Strong-Tie Co., “HDI Drop-In Anchor” by Hilti, Inc., “Smart DI” by DeWalt or “Multi-Set II Drop-In Anchor” by ITW Redhead.

   e. Undercut Anchors: Undercut anchors shall be “HDA Undercut Anchor” by Hilti, Inc., “Atomic Undercut+” by DeWalt or “Torq-Cut” by Simpson Strong-Tie Co.

2. Adhesive Anchors:

   a. Adhesive anchors shall be “Epcon A7” or “Epcon C6+ Adhesive Anchoring System” by ITW Redhead, “HIT HY-200 Adhesive Anchoring System” by Hilti, Inc., “SET Epoxy Tie High Strength Anchoring Adhesive” or “AT High Strength Anchoring Adhesive” by Simpson Strong-Tie Co., or AC100+ Gold” Adhesive Anchoring System” by DeWalt.

   b. Non-structural adhesive anchors systems shall be IBC compliant and capable of resisting short term wind and seismic (Seismic Design Categories A and B) as well as long term and short term sustained static loads in uncracked concrete.

   c. Non-structural adhesive anchor embedment depth of the rod shall provide a minimum allowable bond strength that is equal to the allowable yield capacity of the rod unless noted otherwise on the Drawings.

   d. **No or equal products will be considered unless prequalified and approved by the Engineer and Owner.**

E. Concrete Anchor Rod Materials:

1. Concrete anchors used to anchor structural steel shall be a threaded steel rod per manufacturer's recommendations for proposed adhesive system, but shall not have a yield strength (fy) less than 58 ksi nor an ultimate strength (fu) less than 72.5 ksi, unless noted otherwise. Where steel to be anchored is galvanized, concrete anchors shall also be galvanized unless otherwise indicated on the Drawings.

2. Concrete anchors used to anchor aluminum, FRP, or stainless steel shall be Type 304 stainless steel unless noted otherwise. All underwater concrete anchors shall be Type 316 stainless steel.

3. Nuts, washers, and other hardware shall be of a material to match the anchors.

2.05 MASONRY ANCHORS

(NOT USED)

2.06 WELDS

A. Electrodes for welding structural steel and all ferrous steel shall comply with AWS Code, using E70 series electrodes for shielded metal arc welding (SMAW), or F7 series electrodes for submerged arc welding (SAW).

B. Electrodes for welding aluminum shall comply with the Aluminum Association Specifications and AWS D1.2.

C. Electrodes for welding stainless steel and other metals shall comply with AWS D1.6.

2.07 WELDED STUD CONNECTORS

(NOT USED)

2.08 EYEBOLTS

(NOT USED)

2.09 HASTELLOY FASTENERS

(NOT USED)

2.10 ANTISEIZE LUBRICANT

A. Antiseize lubricant shall be C5-A Anti-Seize by Loctite Corporation, Molykote P-37 Anti-Seize Paste by Dow Corning, 3M Anti-Seize by 3M, or equal.

PART 3 -- EXECUTION

3.01 MEASUREMENTS

A. The Contractor shall verify all dimensions and review the Drawings and shall report any discrepancies to the Engineer for clarification prior to starting fabrication.

3.02 ANCHOR INSTALLATION

A. Anchor Rods, Concrete Anchors, and Masonry Anchors

1. Anchor rods shall be installed in accordance with AISC "Code of Standard Practice" by setting in concrete while it is being placed and positioned by means of a rigidly held template. Overhead adhesive anchors, and base plates or elements they are anchoring, shall be shored as required and securely held in place during anchor setting to prevent movement during anchor installation. Movement of anchors during curing is prohibited.

2. The Contractor shall verify that all concrete and masonry anchors have been installed in accordance with the manufacturer's recommendations and that the capacity of the installed anchor meets or exceeds the specified safe holding capacity.

3. Concrete anchors shall not be used in place of anchor rods without Engineer's approval.

4. All stainless steel threads shall be coated with antiseize lubricant.

B. High Strength Bolts

1. All bolted connections for structural steel shall use high strength bolts. High strength bolts shall be installed in accordance with AISC 348 "The 2009 RCSC Specification for Structural Joints". All bolted joints shall be Type N, snug-tight, bearing connections in accordance with AISC Specifications unless noted otherwise on the Drawings.

C. Concrete Anchors

1. Concrete at time of anchor installation shall be a minimum age of 21 days, have a minimum compressive strength of 2500 psi, and shall be at least 50 degrees F.

2. Concrete anchors designed by the Contractor shall be classified as structural or non-structural based on the requirements indicated above.

3. Concrete Anchor Testing:

a. At all locations where concrete anchors meet the requirements for structural anchors at least 5 percent of all concrete anchors installed shall be proof tested to the value indicated on the Drawings, with a minimum of one tested anchor per anchor group. If no test value is indicated on the Drawings but the installed anchor meets the requirements for structural anchors, the Contractor shall notify the Engineer to allow verification of whether anchor load proof testing is required.

b. Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested, load test values and proposed anchor testing procedure (including a diagram of the testing equipment proposed for use) to the Engineer for review prior to conducting any testing. Proof testing of anchors shall be in accordance with ASTM E488 for the static tension test. If additional tests are required, inclusion of these tests shall be as stipulated on Contract Drawings.

c. Where Contract Documents indicate anchorage design to be the Contractor's responsibility and the anchors are considered structural per the above criteria, the Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested and load test values, sealed by a Professional Engineer currently registered in the State of South Carolina. The Contractor's Engineer shall also submit documentation indicating the Contractor's proof testing procedures have been reviewed and the proposed procedures are acceptable. Proof testing procedures shall be in accordance with ASTM E488.

d. Concrete Anchors shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the anchor after loading shall be considered a failure. Anchors exhibiting damage shall be removed and replaced. If more than 5 percent of tested anchors fail, then 100 percent of anchors shall be proof tested.

e. Proof testing of concrete anchors shall be performed by an independent testing laboratory hired directly by the Contractor and approved by the Engineer. The Contractor shall be responsible for costs of all proof testing, including additional testing required due to previously failed tests.

4. All concrete anchors shall be installed in strict conformance with the manufacturer's printed installation instructions. A representative of the manufacturer shall be on site when required by the Engineer.

5. All holes shall be drilled in accordance with the manufacturer's instructions except that cored holes shall not be allowed unless specifically approved by the Engineer. If cored holes are allowed by the manufacturer and approved by the Engineer, cored holes shall be roughened in accordance with manufacturer requirements. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with the manufacturer's instructions prior to installation of adhesive and threaded rod unless otherwise recommended by the manufacturer. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer. . Injection of adhesive into the hole shall be performed to minimize the formation of air pockets in accordance with the manufacturer's instructions. Wipe rod free from oil that may be present from shipping or handling.

D. Other Bolts

1. All dissimilar metal shall be connected with appropriate fasteners and shall be insulated with a dielectric or approved equal.

2. All stainless steel bolts shall be coated with antiseize lubricant.

3.03 WELDING

A. All welding shall comply with AWS Code for procedures, appearance, quality of welds, qualifications of welders and methods used in correcting welded work.

B. Welded stud connectors shall be installed in accordance with AWS D1.1.

3.04 INSPECTION

A. High strength bolting will be visually inspected in accordance with AISC 348 "The 2009 RCSC Specification for Structural Joints". Rejected bolts shall be either replaced or retightened as required.

B. Field welds will be visually inspected in accordance with AWS Codes. Inadequate welds shall be corrected or redone as required in accordance with AWS Codes.

C. Post-installed concrete anchors shall be inspected as required by ACI 318.

3.05 CUTTING OF EMBEDDED REBAR

A. The Contractor shall not cut embedded rebar cast into structural concrete during installation of post-installed fasteners without prior approval of the Engineer.

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SECTION 05061

STAINLESS STEEL

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. The Contractor shall furnish, install and erect the stainless steel work as shown on the Contract Drawings and specified herein.

B. Stainless steel work shall be furnished complete with all accessories, mountings and appurtenances of the type of stainless steel and finish as specified or required for a satisfactory installation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 - Submittals

B. Section 05010 - Metal Materials

C. Section 05050 - Metal Fastening

D. Section 05500 - Metal Fabrications

1.03 REFERENCES

A. ASTM A193 - Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

B. ASTM A194 - Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

C. ASTM A262 - Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel.

D. ASTM A276 - Stainless and Heat-Resisting Steel Bars and Shapes.

E. ASTM A314 - Stainless and Heat-Resisting Steel Billets and Bars for Forging.

F. ASTM A380 - Practice for Cleaning and Descaling Stainless Steel Parts, Equipment and Systems.

G. ASTM A473 - Stainless and Heat-Resisting Steel Forgings.

H. ASTM A666 - Austenitic Stainless Steel, Sheet, Strip, Plate and Flat Bar.

I. ASTM A774 - Stainless Steel Pipe Fittings

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J. ASTM A778 - Stainless Steel Pipe

K. ASTM F593 - Stainless Steel Bolts, Hex Cap Screws and Studs.

L. ASTM F594 - Stainless Steel Nuts.

M. ANSI/ASME B1.1 - Unified Inch Screw Thread (UN and UNR Thread Form).

1.04 TESTS

A. All stainless steel materials including stainless test welds, shall be checked for compliance with tests for susceptibility to intergranular attack. Such tests shall be Practices A, B and E of ASTM A262. Detailed procedures for the tests shall be submitted to the Engineer for approval prior to start of work. Practice A shall be used only for acceptance of materials but not for rejection of materials, and shall be used for screening material intended for testing in Practice B and Practice E. The maximum acceptable corrosion rate under Practice B shall be 0.004 inch per month, rounded off to the third decimal place. If the certified mill report indicates that such test has been satisfactory performed, the fabricator may not be required to repeat the test. Material passing Practice E shall be acceptable.

B. Sample selection for the susceptibility to intergranular attack tests shall be as follows:

1. One (1) sample per heat treatment lot for plates and forgings;

2. One (1) sample per each Welding Procedure Qualification regardless of the joint design;

3. If tests indicate a reduction in corrosion resistance, welding procedure shall be adjusted or heat treatment determined as needed to restore required corrosion resistance.

4. The samples so chosen shall have received all the post-weld heat treatments identical to the finished part.

1.05 SUBMITTALS

A. The Contractor shall prepare and submit for approval shop drawings for all stainless steel fabrication in accordance with Section 01300, Submittals.

B. Submittals shall include, but not be limited to, the following:

1. Certified test reports for susceptibility to intergranular attack.

2. Affidavit of compliance with type of stainless steel shown on the Contract Drawings or specified herein.

3. Certified weld inspection reports.

4. Cleaning and handling of stainless steel in accordance with Paragraph 3.04, Cleaning and Handling.

C. Samples of finish, on each type of stainless steel to be furnished, shall be submitted to the Engineer upon request.

1.06 QUALITY ASSURANCE

A. Shop inspections may be made by the Engineer. The Contractor shall give ample notice to the Engineer prior to the beginning of any stainless steel fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the works.

B. Inspectors shall have the authority to reject any materials or work which does not meet the requirements of the Contract Drawings or the Specifications.

C. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship.

1.07 HANDLING, STORAGE AND DELIVERY

A. Mechanical damage (e.g., scratches and gouges) to the stainless steel material shall not be permitted and is cause for rejection. Care shall be taken in the material handling since such mechanical damage will result in the passive oxide film being "punctured" leading to a possible lower resistance to the initiation of corrosion than the surrounding chemically-passivated surface.

B. Stainless steel plates and sheets shall be stored vertically in racks and not be dragged out of the racks or over one another. Racks shall be protected to prevent iron contamination.

C. Heavy stainless steel plates shall be carefully separated and chocked with wooden blocks so that the forks of a fork-lift could be inserted between plates without mechanically damaging the surface.

D. Stainless steel plates and sheets laid out for use shall be off the floor and be divided by wooden planks to prevent surface damage and to facilitate subsequent handling.

E. Plate clamps, if used, shall be used with care as the serrated faces can dig in, indent and gouge the surface.

F. Stainless steel fabrications shall be loaded in such a manner that they may be transported and unloaded without being overstressed, deformed or otherwise damaged.

G. Stainless steel fabrications and packaged materials shall be protected from corrosion and deterioration and shall be stored in a dry area. Materials stored outdoors shall be supported above ground surfaces on wood runners and protected with approved effective and durable covers.

H. Stainless steel fabrications shall not be placed in or on a structure in a manner that might cause distortion or damage to the fabrication. The Contractor shall repair or replace damaged stainless steel fabrications or materials as directed by the Engineer.

1.08 FIELD MEASUREMENTS

A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.

B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

PART 2 -- PRODUCTS

2.01 MATERIALS AND FINISHES

A. Stainless steel shall be Type 304 unless it is used for underwater service. Stainless steel for underwater service shall be Type 316. Minimum mechanical finish shall be No. 4 as stated in Table 2 unless otherwise noted on the Contract Drawings.

B. The basic mill forms (sheet, strip, plate and bar) are classified by size as shown on Table 1. Tables 2, 3 and 4 identify finishes and conditions in which sheet, bar and plate are available.

C. Tables 2, 3 and 4 show numbered finishes and conditions for sheet, bar and plate. While there are no specific designations for polished finishes on bar or plate, the sheet finish designations are used to describe the desired effect. This also applies to finishes on ornamental tubing.

D. There are three standard finishes for strip, which are broadly described by the finishing operations employed:

1. No. 1 Strip Finish

   No. 1 strip finish is approximately the same as No. 2D Sheet Finish. It varies in appearance from dull gray matte to a fairly reflective surface, depending largely on alloy composition and amount of cold reduction.

2. No. 2 Strip Finish is approximately the same as a No. 2B sheet finish. It is smoother, more reflective than No. 1, and likewise varies with alloy composition.

3. Bright annealed finish is a highly reflective finish that is retained by final annealing in a controlled atmosphere furnace.

Table 1

Classification of Stainless Steel Product Form

Item	Description	Dimensions		
		Thickness	Width	Diameter or Size
Sheet	Coils and cut length: Mill finishes Nos. 1, 2D and 2B Polished finishes Nos. 3, 4, 6, 7 & 8	 under 3/16" under 3/16"	 24" and over all widths	 -- --
Strip	Cold finished, coils or cut lengths Polished finishes Nos. 3, 4, 6,7 & 8	under 3/16" under 3/16"	under 24" all widths	-- --
Plate	Flat rolled or forged	3/16" and over	over 10"	--
Bar	Hot finished rounds, squares, octagons and hexagons Hot finished flats Cold finished rounds, squares, octagons and hexagons Cold finished flats	-- 1/8" to 8" incl. -- 1/8" to 4-1/2"	-- 1/4" to 10" incl. -- 3/8" to 4-1/2"	1/4" and over -- over 1/8" --
Wire	Cold finishes only: (in coil) Round, square, octagon, hexagon and flat wire	 under 3/16"	 under 3/8"	 --
Pipe & Tubing	Several different classifications, with differing specifications, are available.			
Extrusion	Not considered “standard” shapes. Currently limited in size to approximately 6-1/2" diameter or structurals.			

Table 2

Standard Mechanical Sheet Finishes

Unpolished or Rolled Finishes: No. 1 A rough dull surface which results from hot rolling to the specified thickness followed by annealing and descaling.	No. 4 A polished surface obtained by finishing with a 120-150 mesh abrasive, following initial grinding with coarser abrasives. This is a general purpose bright finish with a visible "grain" which prevents mirror reflection.
No. 2D A dull finish which results from cold rolling followed by annealing and descaling, and may perhaps get a final light roll pass through unpolished rolls. A 2D finish is used where appearance is of no concern.	No. 6 A dull satin finish having lower reflectivity than No. 4 finish. It is produced by Tampico brushing the No. 4 finish in a medium of abrasive and oil. It is used for architectural applications and ornamentation where a high luster is undesirable, and to contrast with brighter finishes.
No. 2B A bright cold-rolled finish resulting in the same manner as No. 2D finish, except that the annealed and descaled sheet receives a final light roll pass through polished rolls. This is the general purpose cold-rolled finish that can be used as is, or as a preliminary step to polishing.	No. 7 A high reflective finish that is obtained by buffing finely ground surfaces but not to the extent of completely removing the "grit" lines. It is used chiefly for architectural and ornamental purposes.
Polished Finishes: No. 3 An intermediate polish surface obtained by finishing with a 100 grit abrasive. Generally used where a semi-finished polished surface is required. A No. 3 finish usually receives additional polishing during fabrication.	No. 8 The most reflective surface, which is obtained by polishing with successively finer abrasives and buffing extensively until all grit lines from preliminary grinding operations are removed. It is used for applications such as mirrors and reflectors.

Table 3

Conditions and Finishes for Bar

Conditions	Surface Finishes[1]
Hot worked only	(a) Scale not removed (excluding spot conditioning) (b) Rough turned[2] (c) Pickled or blast cleaned and pickled.
Annealed or otherwise heat treated.	(a) Scale not removed (excluding spot conditioning) (b) Rough turned (c) Pickled or blast cleaned and pickled (d) Cold drawn or cold rolled (e) Centerless ground (f) Polished
Annealed and cold worked to high tensile strength[3]	(d) Cold drawn or cold rolled (e) Centerless ground (f) Polished

1 Surface finishes (b), (e) and (f) are applicable to round bars only.

2 Bars of the 4xx series stainless steels which are highly hardenable, such as Types 414, 420, 420F, 431, 440A, 440B and 440C, are annealed before rough turning. Other hardenable grades, such as Types 403, 410, 416 and 416Se, may also require annealing depending on their composition and size.

3 Produced in Types 302, 303Se, 304 and 316.

Table 4

Conditions and Finishes for Plate

Condition and Finish	Description and Remarks
Hot rolled	Scale not removed. Not heat treated. Plates not recommended for final use in this condition.[4]
Hot rolled, annealed or heat treated	Scale not removed. Use of plates in this condition is generally confined to heat resisting applications. Scale impairs corrosion resistance.[1]
Hot rolled, annealed or heat treated, blast cleaned or pickled	Condition and finish commonly preferred for corrosion resisting and most heat resisting applications.
Hot rolled, annealed, descaled and temper passed	Smoother finish for specialized applications.
Hot rolled, annealed, descaled cold rolled, annealed, descaled, optionally temper passed	Smooth finish with greater freedom from surface imperfection than the above.
Hot rolled, annealed or heat treated, surface cleaned and polished	Polished finishes refer to Table 2.

[4] Surface inspection is not practicable on plates which have not been pickled or otherwise descaled.

PART 3 -- EXECUTION

3.01 FABRICATION

A. Holes for bolts and screws shall be drilled. Fastenings shall be concealed where practicable. Joints exposed to the weather shall be formed to exclude water.

B. As far as practicable, all fabricated units shall be fitted and assembled in the shop, with all cuts and bends made to precision measurements in accordance with details shown on approved shop drawings.

C. Work shall be fabricated so that it is installed in a manner that will provide for expansion and contraction, prevent the shearing of bolts, screws and other fastenings, ensure rigidity, and provide close fitting of sections.

D. All finished and/or machined faces shall be true to line and level. Stainless steel sections shall be well formed to shape and size with sharp lines and angles; curved work shall be sprung evenly to curves.

E. All work shall be fitted together at the shop as far as possible, and delivered complete and ready for erection. Proper care shall be exercised in handling all work so as not to injure the finished surfaces.

3.02 WELDING

A. Welding shall be done in a manner that will prevent buckling and in accordance with Specification 05050 – Metal Fastening, and as modified hereinafter.

B. All welds exposed in the work shall be ground smooth and finished to match the finish of the adjacent stainless steel surfaces.

C. Select weld rods that provide weld filler metal having corrosion resistant properties as nearly identical or better than the base metal to insure preservation of the corrosion-resistant properties. Provide heat treatment at welds where testing of weld procedure indicates it is required to restore the corrosion resistance.

D. Thermal conductivity of stainless steel is about half that of other steels; and the following methods may be used to accommodate this situation:

1. Use lower weld current setting.

2. Use skip-weld techniques to minimize heat concentration.

3. Use back-up chill bars or other cooling techniques to dissipate heat.

E. Edges of the stainless steel to be welded shall be cleaned of contaminants.

3.03 FASTENERS

A. Stainless steel fasteners shall be used for joining stainless steel work.

B. Stainless steel fasteners shall be made of alloys that are equal to or more corrosion resistant than the materials they join.

3.04 CLEANING AND HANDLING

A. All stainless steel surfaces shall be precleaned, descaled, passivated and inspected before, during and after fabrication in accordance with the applicable sections of ASTM A380 and as detailed in the procedures to be submitted to the Engineer for approval prior to start of work. Degreasing and passivation of stainless steel articles shall be conducted as the last step after fabrication.

B. Measures to protect cleaned surfaces shall be taken as soon as final cleaning is completed and shall be maintained during all subsequent handling, storage and shipping.

1. The Contractor shall submit for approval specific procedures listing all the steps to be followed in detecting contamination and in descaling, cleaning, passivation and protecting of all stainless steel.

2. Area showing clear indications of contamination shall be recleaned, repassivated and reinspected.

C. At approved stages in the shop operations, contaminants such as scale, embedded iron, rust, dirts, oil, grease and any other foreign matter shall be removed from the metal, as directed or approved by the Engineer. The adequacy of these operations shall be checked by the Engineer. Operations in the shop shall be conducted so as to avoid contamination of the stainless steel and to keep the metal surfaces free from dirt and foreign matter.

D. In order to prevent incipient corrosion during fabrication, special efforts shall be made at all times to keep all stainless steel surfaces from coming in contact with other metals.

1. Stainless steel and stainless steel welds shall be cleaned with clean sand free of iron, stainless steel wool, stainless steel brushes, or other approved means and shall be protected at all times from contamination by any materials, including carbon steel, that shall impair its resistance to corrosion.

2. Approved methods of cutting, grinding and handling shall be used to prevent contamination. If air-arc, or carbon-arc cutting is used, additional metal shall be removed by approved mechanical means so as to provide clean, weldable edges. All grinding of stainless steel shall be performed with aluminum oxide or silicon carbide grinding wheels bonded with resin or rubber. Grinding wheels used on carbon steel shall not be used on stainless steel.

3. Sand, grinding wheels, brushes and other materials used for cleaning stainless steel shall be checked periodically by the Engineer for contaminants. Cleaning aids found to contain contaminants shall not be used on the work.

3.05 INSTALLATION

A. All stainless steel fabrications shall be erected square, plumb and true, accurately fitted, adequately anchored in place, set at proper elevations and positions.

B. All inserts, anchor rods and all other miscellaneous work specified in the Detailed Specifications or shown on the Contract Drawings or required for the proper completion of the work, which are embedded in concrete, shall be properly set and securely held in position in the forms before the concrete is placed.

C. All stainless steel fabrications shall be installed in conformance with details shown on the Contract Drawings or on the approved shop drawings.

-END OF SECTION -

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SECTION 05140

STRUCTURAL ALUMINUM

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all equipment, labor, materials, and services required to provide all structural aluminum work in accordance with the Contract Documents. The term "structural aluminum" shall include items as defined in the Aluminum Association "Specifications for Aluminum Structures".

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05050 - Metal Fastening

C. Section 09900 - Painting

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of the Bid.

1. South Carolina Building Code

2. Aluminum Association "Specifications for Aluminum Structures"

3. AWS D1.2 - "Structural Welding Code".

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Certified Mill Test Reports

2. Affidavit of Compliance with grade specified

3. Shop Drawings which include the following:

a. Layout drawings indicating all structural shapes, sizes, and dimensions.

b. Beam and column schedules.

c. Detailed drawings indicating jointing, anchoring and connection details.

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1.05 QUALITY ASSURANCE

A. Shop inspection may be required by the Owner at his own expense. The Contractor shall give ample notice to the Engineer prior to the beginning of any fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the work. Inspectors shall have the authority to reject any materials or work which do not meet the requirements of these Specifications. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship under this Specification.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Structural aluminum shall comply with Section 05010, Metal Materials.

B. Fasteners for structural aluminum shall be in accordance with Section 05050, Metal Fastening.

C. Electrodes for welding shall be in accordance with Section 05050, Metal Fastening.

PART 3 -- EXECUTION

3.01 MEASUREMENT

A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of work. The Contractor shall review the Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

3.02 FABRICATION

A. Fabrication shall be in accordance with the Aluminum Association "Specifications for Aluminum Structures". Fabrication shall begin only after Shop Drawing approval.

B. Except where otherwise noted on the Drawings or in this Specification, all shop connections shall be welded.

C. All holes in structural aluminum members required for anchors, anchor rods, bolts, or other members or for attachment of other work shall be provided by the fabricator and detailed on the Shop Drawings.

D. All materials shall be properly worked and match-marked for field assembly.

3.03 DELIVERY, STORAGE AND HANDLING

A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.

B. Structural aluminum members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. The Contractor shall repair or replace damaged materials or structures as directed.

3.04 ERECTION

A. All temporary bracing, guys and bolts as may be necessary to ensure the safety of the structure until the permanent connections have been made shall be provided by the Contractor.

B. Structural members shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before being permanently fastened.

C. No cutting of structural aluminum members in the field will be allowed except by the written approval of the Engineer.

D. Bearing surfaces and other surfaces which will be in permanent contact shall be cleaned before assembly.

E. Field welding shall not be permitted unless specifically indicated in the Drawings or approved in writing by the Engineer. All field welding shall comply with Section 05050, Metal Fastening.

F. All bolted connections shall comply with Section 05050, Metal Fastening.

G. All field connections shall be accurately fitted up before being bolted. Drifting shall be only such as will bring the parts into position and shall not be sufficient to enlarge the holes or to distort the metal. All unfair holes shall be drilled or reamed.

H. Misfits at Bolted Connections

1. Where misfits in erection bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.

2. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins. The Contractor shall notify the Engineer immediately and shall submit a proposed method of remedy for review by the Engineer.

3. Where misalignment between anchor bolts and bolt holes in aluminum members are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misalignment for review by the Engineer.

I. Grouting of Base Plates and Bearing Plates

1. The bottom surface of the plates shall be cleaned of all foreign materials, and concrete or masonry bearing surface shall be cleaned of all foreign materials and roughened to improve bonding.

2. Accurately set all base and bearing plates to designated levels with steel wedges or leveling plates.

3. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure. Non-shrink grout shall conform to Section 03600, Grout.

4. Anchor bolts shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its specified strength.

J. Where finishing is required, assembly shall be completed including bolting and welding of units before start of finishing operations.

3.05 PAINTING

A. Painting shall be performed according to Section 09900, Painting.

B. Aluminum surfaces in contact with concrete or dissimilar metals shall be thoroughly protected with two coats of epoxy paint with a minimum total thickness of 16 mils or other approved isolating material in accordance with the requirements of Section 09900 - Painting.

- END OF SECTION -

SECTION 05500

METAL FABRICATIONS

PART 1 -- GENERAL

1.01 REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all metal fabrications not specifically included in other Sections, complete and in accordance with the requirements of the Contract Documents.

B. Work shall include but may not be limited to guard posts and pipe supports.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05050 - Metal Fastening

C. Section 05035 - Galvanizing

D. Certain specific items are included in other Sections of the Specifications. See the section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. AISC - Specification for Structural Steel Buildings

3. AISI - Specifications for the Design of Cold-Formed Steel Structural Members

4. Aluminum Association Specifications for Aluminum Structures

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection drawings of all metalwork specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials, and Section 05050, Metal Fastening.

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PART 2 -- PRODUCTS

2.01 METAL MATERIALS

A. Metal materials used in metal fabrications shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used in metal fabrication shall conform to Section 05050, Metal Fastening, unless noted otherwise.

2.03 LINTELS

(NOT USED)

2.04 GUARD POSTS (BOLLARDS)

A. Guard posts shall be 6-inch diameter Schedule 40 galvanized steel pipe in accordance with ASTM A53.

B. Guard posts shall be concrete filled and crowned, as detailed in the Drawings.

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050, Metal Fastening. All fastenings shall be concealed where practicable.

G. Fabricated items shall be shop painted when specified in Section 09900, Painting.

3.02 INSTALLATION

A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.

B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions

C. Metal work shall be field painted when as specified in accordance with Section 09900, Painting.

- END OF SECTION -

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SECTION 05510

METAL STAIRS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all metal stairs in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05050 - Metal Fastening

D. Section 05120 - Structural Steel

E. Section 05140 - Structural Aluminum

F. Section 05520 - Handrails and Railings

G. Section 05531 - Gratings, Access Hatches, and Access Doors

H. Section 05550 - Stair Treads and Nosings

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. AISC Specification for Structural Steel Buildings

3. AISI Specification for the Design of Cold-Formed Steel Structural Members

4. Aluminum Association Specifications for Aluminum Structures

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1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Complete fabrication and erection drawings of all metal work specified herein.

2. Other submittals as required in accordance with Section 05010 - Metal Materials, and Section 05050 - Metal Fastening.

PART 2 -- PRODUCTS

2.01 METAL MATERIALS

A. Metal materials used for metal stairs shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used in metal stairs shall conform to Section 05050, Metal Fastening, unless noted otherwise.

2.03 METAL STAIRS AND LANDINGS

A. Stair stringers and structural framing of landings shall be fabricated from steel or aluminum as indicated on the Drawings.

1. Steel stairs shall be fabricated from steel in accordance with Section 05120, Structural Steel.

2. Aluminum stairs shall be fabricated from aluminum alloy 6061-T6 in accordance with Section 05140, Structural Aluminum.

B. Regardless of material of stringers, all stair treads shall be aluminum in accordance with Section 05550, Stair Treads and Nosings.

C. Where metal landings are required as indicated on the Drawings, gratings at landings shall conform to Section 05531, Gratings, Access Hatches, and Access Doors.

D. Handrails for metal stairs shall conform to Section 05520, Handrails and Railings. Contractor shall coordinate attachment of handrails to metal stairs.

E. All clips, anchors, and necessary appurtenances shall be provided for a complete and rigid installation.

F. Closure plates shall be provided for all exposed ends of stringers.

G. All exposed connections shall be welded and ground smooth, unless otherwise indicated on the Drawings.

H. Stairs and landings shall be designed to support a 100 psf live load, minimum, unless otherwise indicated on the Drawings.

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with all adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. Finished members shall conform to the lines, angles, and curves shown on the drawings and shall be free from distortions of any kind.

E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050, Metal Fastening. All fastenings shall be concealed where practicable.

G. Fabricated items shall be shop painted when specified in accordance with Section 09900, Painting.

3.02 INSTALLATION

A. Assembly and installation of metal stairs shall be performed in strict accordance with manufacturer's recommendations.

B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

C. Metal stairs shall field painted when specified in accordance with Section 09900, Painting.

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SECTION 05520

HANDRAILS AND RAILINGS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all handrails and railings in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05050 - Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. Aluminum Association Specifications for Aluminum Structures

3. Occupational Safety and Health Administration (OSHA) Regulations

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection drawings of all metal work specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials and Section 05050, Metal Fastening.

PART 2 -- PRODUCTS

2.01 METAL MATERIALS

A. Metal materials used for handrails and railings shall conform to Section 05010, Metal Materials, unless noted otherwise.

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2.02 METAL FASTENING

A. All welds and fasteners used in handrails and railings shall conform to Section 05050, Metal Fastening, unless noted otherwise.

2.03 HANDRAILS AND RAILINGS

A. General - Handrail systems shall consist of all railings, posts, toeboards, baseplates, anchors, and accessories required for a complete and rigid installation.

1. All handrail systems shall be fabricated from extruded aluminum alloy 6061-T6 or 6105-T5, with Aluminum Association M12C22A41 finish, unless otherwise noted.

2. Metal railings shall be fabricated from 1-1/2 inch Schedule 40 pipe. Metal railing support posts shall be fabricated from 1-1/2 inch Schedule 80 pipe.

3. The centerline of the top guard rail shall be 42 inches above the walking surface for level rail. For stair rail, the centerline of the top guard rail shall be 42 inches above the leading edge of the tread nosing. Stair handrail shall be 34 inches above the leading edge of the tread nosing. See Standard Detail 0552000.

4. Posts

a. Maximum horizontal spacing between posts for level rail shall be six feet.

b. Maximum horizontal spacing between posts for stair rail shall be five feet.

5. All rail joints shall be finished flush and shall occur only at supports. Posts shall not interrupt the continuation of the top rail at any point along the railing, including corners and end terminations. The top surface of the top railing shall be smooth and shall not be interrupted by projecting fittings.

6. Toeboards

a. Toeboards shall project 4-inches above the walking surface and shall not infringe on the minimum required walkway width.

b. Aluminum toeboards shall be extruded from aluminum alloy 6063-T6 unless otherwise noted.

c. Toeboards shall have a minimum thickness of 1/8" at any point. Geometry of toeboard shall closely resemble geometry shown on Drawings.

7. Expansion joint splices shall be provided at 30 foot maximum spacing and at all expansion joints in the structure supporting the handrail.

8. The handrail system shall be designed to resist the design loads specified by both OSHA and the South Carolina Building Code.

9. Provide handrail extensions at top and bottom of stairs and ramps in accordance with the South Carolina Building Code.

B. For metal handrail, the Contractor shall have the option of providing a handrail system of either an all welded type construction or a component type construction.

1. With both the all welded or component type construction, the baseplates and toeboards shall be furnished as shown on the Drawings.

2. Component Type System

a. All fittings and brackets shall be designed for stainless steel concealed set screws with internal tyne type connectors.

b. Exposed fittings shall be cast or extruded aluminum, or stainless steel to match ladder material, except where corrosion-resistant steel is employed as a standard fabricator's item for use.

c. Component type handrail shall be as manufactured by Thompson Fabricating Company, Inc., or Hollaender Manufacturing Company, Inc.

3. Welded handrail may be field assembled using component type fittings as described herein.

C. Handrail shall be either Type I or Type II handrail as shown on the Drawings. If no type is indicated on Drawings, handrail shall be Type I.

1. Type I handrail shall be a two-rail system. The centerline of the intermediate rail shall be 21 inches above the walking surface.

2. Type II handrail shall be a three-rail system with vertical posts spanning between the two intermediate rails.

a. The centerline of the lower intermediate rail shall be 7 inches above the walking surface.

b. The centerline of the upper intermediate rail shall be 5-3/4" below the centerline of the top rail.

c. Vertical posts spanning between the intermediate rails shall be 1/2" diameter schedule 40 pipe or fiberglass rod.

d. Spacing of vertical posts shall be as required to prevent passage of a 4-inch sphere at any point.

D. Where gates are required in handrails as shown on the Drawings, they shall be self-closing and shall be provided by the same manufacturer as the handrail. Gates shall swing away from the opening being protected by the handrail.

E. Where safety chains are required in handrails as shown on the Drawings, chains shall be constructed of Type 304 stainless steel. Chains shall be straight link style, 3/16-inch diameter, with at least twelve links per foot, and with snap hooks on each end. Snap hooks shall be boat type and eye bolts for attachment of chains shall be 3/8-inch bolts with 3/4-inch eye diameter welded to the railing posts. Two (2) chains, four inches longer than the anchorage spacing shall be supplied for each guarded area.

2.04 FREE STANDING RAILING SYSTEM

A. Free standing railing system shall be installed on roof ledges where accessible equipment is provided on roof and roof does not have a perimeter parapet wall of a minimum height of 42 inches. Free standing railing system shall be Safety Rail 2000 Guardrail System by BlueWater Mfg., Inc. or approved equal.

B. Toe Board brackets shall be used when the parapet wall is less than 3-1/2” in height.

C. Performance Characteristics: Shall meet and exceed OSHA (Standards - 29 CFR) 1926.502 (b).

1. Railing System shall be designed to withstand a minimum 200 pounds of test load in any direction.

2. Railing System shall consist of a top rail and rail at mid height between top rail and walking surface.

3. Railing system shall extend to a height of at least 42" from the finished roof deck.

4. Railing system shall be free of sharp edges and snag points.

D. Railing and Base

1. Rail shall be 1 5/8” O.D. Hot Rolled Pickled Electric Weld Tubing

2. Each support post shall have a free standing base cast from Class 30 Gray Iron material.

3. Each base shall have four (4) receiver posts for accepting the rails.

4. The receiver posts shall have a positive locking system. A friction locking system will not be acceptable.

5. The receiver posts shall have a slot to enable the rails to be mounted in any direction.

E. Hardware

1. The securing pins shall be made from 1010 carbon steel. The pins shall be zinc plated and yellow chromate dipped. The pins shall consist of a collared pin and a lanyard that connects to a lynch pin.

2. For Gate Assemblies Only. Bolts and washers shall be 3/8" x 3 ½" and 3/8" x 3" grade 5, zinc plated.

3. Finish: Rails: Specify factory finish Safety Yellow Powder Coat Paint, Hot Dipped Galvanized or a color to match the building.

Bases: Specify factory finish Safety Yellow Powder Coat Paint, Hot Dipped Galvanized or a color to match the building.

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with all adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. Finished members shall conform to the lines, angles, and curves shown on the drawings and shall be free from distortions of any kind.

E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

F. Concrete anchors and bolts for attachment of handrail baseplates to supporting members shall conform to Section 05050, Metal Fastening.

G. All fabricated items shall be shop painted in accordance with Section 09900, Painting.

3.02 INSTALLATION

A. Assembly and installation of handrails and railings shall be performed in strict accordance with manufacturer's recommendations.

B. All handrails and railings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

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SECTION 05531

GRATINGS, ACCESS HATCHES, AND ACCESS DOORS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all gratings, floor plates, and hatches in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05050 - Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. Aluminum Association Specifications for Aluminum Structures

3. Occupational Safety and Health Administration (OSHA) Regulations

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection Drawings of all gratings, access hatches, and access doors specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials, and Section 05050, Metal Fastening.

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PART 2 -- PRODUCTS

2.01 METAL MATERIALS

A. Metal materials used for gratings, floor plates, and hatches shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used for gratings, floor plates, and hatches shall conform to Section 05050, Metal Fastening, unless noted otherwise.

2.03 GRATING

A. General - Grating, including support frames, fastenings, and all necessary appurtenances for a complete installation, shall be furnished as indicated on the Drawings.

1. All exposed bearing ends of grating shall be enclosed in a perimeter band of the same dimensions and material as the main bars, including ends at all cutouts.

2. Grating shall be fabricated into easily removable sections and shall be fastened at each corner and as required with fasteners provided by the grating manufacturer. No fasteners shall be permitted to project above the walking surface.

3. Grating shall be designed for a loading of 150 psf unless otherwise required by the Drawings. Grating deflection shall not exceed 1/4 inch under a uniform load of 100 psf. Minimum grating depth shall be 1-1/2 inches, unless structural requirements based on clear span require more depth.

4. Grating installed in cast-in-place concrete shall be provided with embedded support frames on all perimeter and bearing edges. Support frames shall include anchor straps or headed studs at a maximum of 18" on-center, a minimum of two each side. Support frames shall be fabricated from the same material as the grating.

B. Aluminum Grating

1. Aluminum grating shall be of I-bar type and shall consist of extruded bearing bars positioned and locked by crossbars. All supports, cross members, etc. shall be aluminum. Plank clips for grating holddowns or other required attachments, shall be aluminum or stainless steel. Bolts shall be stainless steel. Provide embedded aluminum support frames for cast-in-place concrete installations.

2. Grating shall be "19-SI-4 I-Bar Swage Locked" by Alabama Metal Industries Corporation (AMICO), "IB" by Harsco Industrial IKG, "I-Bar 19SGI4", by Ohio Grating Inc., or "I-Bar" by Thompson Fabricating LLC.

C. Aluminum Plank Grating

(NOT USED)

D. Heavy Duty Steel Grating

(NOT USED)

2.04 ACCESS HATCHES

(NOT USED)

2.05 ACCESS DOORS

(NOT USED)

2.06 FALL THROUGH PREVENTION SYSTEM

(NOT USED)

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050, Metal Fastening. All fastenings shall be concealed where practicable.

3.02 INSTALLATION

A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.

B. All gratings, access hatches, and access doors shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions. Embedded support frames shall be set level and square.

C. Grating shall not be field cut or modified unless approved by Engineer.

D. Grating shall not be used for equipment support or anchorage.

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SECTION 05540

CASTINGS

PART 1 -- GENERAL

1.01 REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all castings in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02604 – Utility Structures

B. Section 05010 - Metal Materials

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection drawings of all castings specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials, and Section 05050, Metal Fastening.

PART 2 -- PRODUCTS

2.01 METAL MATERIALS

A. Metal materials used for castings shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used for castings shall conform to Section 05050, Metal Fastening, unless noted otherwise.

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2.03 IRON CASTINGS

A. General - Iron Castings shall include, but not be limited to frames, covers, and grates for trench drains, catch basins, and inlets/.

1. Castings shall be of gray iron of uniform quality, free from defects, smooth and well cleaned by shotblasting.

2. Catalog numbers on the Drawings are provided only to show required types and configuration. All covers shall be cast with raised letters as designated on the Drawings.

3. Castings shall be as manufactured by Dewey Brothers, or Neenah Foundry Company.

B. Covers and Grates

1. Covers and grates shall be provided with matching frames. Cover shall fit flush with the surrounding finished surface. The cover shall not rock or rattle when loading is applied.

2. Round covers and frames shall have machined bearing surfaces.

3. Design loadings:

a. Where located within a structure, a minimum design loading of 300 psf shall be used, unless noted otherwise.

b. At all locations not within a structure, the design loading shall be a standard AASHTO H-20 truck loading, unless otherwise noted.

C. Watertight gasketing, bolting, locking devices, patterns, lettering, pickholes, vents, or self-sealing features shall be as detailed on the Drawings.

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

C. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

3.02 INSTALLATION

A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.

B. All castings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

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SECTION 05550

STAIR TREADS AND NOSINGS

PART 1 -- GENERAL

1.01 REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all stair treads and nosings in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05050 - Metal Fastening

C. Section 05510 - Metal Stairs

D. Section 06610 - Glass Fiber and Resin Fabrications

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code

2. Aluminum Association Specifications for Aluminum Structures.

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection drawings of all work specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials, and Section 05050, Metal Fastening.

PART 2 -- PRODUCTS

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2.01 METAL MATERIALS

A. Metal materials used for stair treads and nosings shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used for stair treads and nosings shall conform to Section 05050, Metal Fastening, unless noted otherwise.

2.03 SAFETY STAIR NOSINGS

A. Abrasive cast aluminum, safety stair nosings shall be provided on all concrete or concrete filled steel pan stairs, including the top stair of metal stairs that attach to concrete, and as shown on the Drawings unless noted otherwise.

B. Nosing shall be 3 inches wide and shall extend the full width of the stairway minus 3 inches on either side. Nosing shall be cast into the concrete and held in place with butterfly type extruded anchors.

C. The nosing shall be "Style 231-A", by Amstep Products, “Alumogrit Type 101", by Wooster Products, Inc., "Type AX", by Safe-T-Metal Company. For steel pan concrete filled stairs, nosing shall be "Type 101-SP", Wooster Products, Inc., or "Type AXPE", by Safe-T-Metal Company. For pan stairs, nosing shall be continuous over corner of stair treads to fully protect corner of treads from abrasion. All exposed fasteners shall be Type 304 stainless steel.

2.04 STAIR TREADS

A. Stair treads shall be aluminum with an abrasive nosing as shown on the Drawings.

B. Stair treads shall be designed for the live load specified in Section 05510, Metal Stairs.

C. Stair treads shall be as manufactured by IKG Industries, or Safe-T-Metal Company.

2.05 FRP STAIR NOSINGS

(NOT USED)

2.06 FRP STAIR TREADS

(NOT USED)

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, connections, brackets, and other details necessary for a complete installation shall be provided.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

E. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050, Metal Fastening. All fastenings shall be concealed where practicable.

3.02 INSTALLATION

A. Assembly and installation of stair treads and nosings shall be performed in strict accordance with manufacturer's recommendations.

B. All stair treads and nosings shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions.

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SECTION 05830

BEARING DEVICES AND ANCHORING

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. The Contractor shall furnish and install bearing plates, pads, expansion devices, anchor rods and bolts and/or other devices used in conjunction with bearings and anchoring of bearing devices and assemblies at supports in accordance with this item and in conformity with the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05050 - Metal Fastening

D. Section 05120 - Structural Steel

E. Section 05140 - Structural Aluminum

F. Section 09900 - Painting

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all work specified hereunder shall conform to the applicable requirements of the following documents to the extent that the provisions of such documents are not in conflict with the requirements of this Section.

1.	RMA Rubber Handbook	A4-F3-T.063-B2, Grade 2, Method B
2.	ASTM A240,	Standard Specification for Heat Resisting Chromium and Chromium - Nickel Stainless Steel Plate and Sheet
3.	ASTM A480	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip
4.	ASTM D395, Method B	Standard Test for Rubber Property – Compression Set
5.	ASTM D412	Standard Test for Rubber Properties In Tension

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6.	ASTM D471	Standard Test for Rubber Property - Effect of Liquids
7.	ASTM D573	Standard Test for Rubber-Deterioration In Air Oven
8.	ASTM D575, Method A	Standard Test for Rubber Properties In Compression
9.	ASTM D624, Die C	Standard Test for Rubber Property - Tear Resistance
10.	ASTM D746	Standard Test for Brittleness Temperature of Plastics and Elastomers by Impact
11.	ASTM D792	Standard Test for Specific Gravity and Density of Plastics by Displacement
12.	ASTM D1149	Standard Test for Rubber Deterioration - Surface Ozone Cracking In a Chamber (Flat Specimens)
13.	ASTM D1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40
14.	ASTM D2240	Standard Test for Rubber Property - Durometer Hardness
15.	ASTM D2256	Standard Test for Breaking Load (Strength) and Elongation of Yarn by the Single-Strand Method
16.	ASTM D4894	Standard Specification for PTFE Granular Molding and RPM Extension Materials
17.	ASTM D4895	Standard Specification for PTFE Resin Produced From Dispersion

1.04 SUBMITTALS

A. Submit the following in accordance with the requirements of Section 01300, Submittals:

1. Certification of compliance that the materials furnished under this section meet and conform to the property and physical requirements, including all testing, as stated herein and as referenced. Specifically, the certification shall state compliance with the applicable standards (ASTM, ANSI, etc.) for fabrication and testing.

2. Shop Drawings for all materials, including installation and adjustment instructions. Included with the Shop Drawings shall be all material certifications, mill test results, working drawings, etc., which are required by this and other applicable sections of the Specifications.

PART 2 -- PRODUCTS

2.01 ELASTOMERIC BEARING PADS

A. The elastomer portion of pads shall be new neoprene compound. Pads shall be cast under heat and pressure and may be individually molded or cut from pressure-cast stock. Variations from the dimensions shown on the Drawings shall not be more than the following: thickness, ±1/16 inch; width, -1/8 to +1/4 inch; length, -1/8 to +1/4 inch. Tolerances, dimensions, finish and appearance, flash, and rubber-to-metal bonding shall conform to the requirements of A 4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be furnished in one piece and shall not be laminated unless otherwise specified. Pads shall be furnished in identifiable packages.

B. Adhesive for use with elastomer pads shall be an epoxy-resin compound compatible with the elastomer having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces. Adhesive shall be 20^{+}F Contact Cement by Miracle Adhesives Corporation, Neoprene Adhesive 77-198 by IGI Adhesives, Sikodur 31, Hi-Mod Gel by Sika Corporation, or DP-605 NS Urethane Adhesive by 3M Adhesive Systems.

C. Laminated pads shall consist of alternate laminations of elastomer and hot-rolled steel sheets molded together as a unit. Outer metal laminations shall be 3/16 inch, and inner laminations shall be 14 gage. Outer laminations of elastomer shall be 1/4 inch, and inner laminations shall be of equal thickness (at least 3/8 but not more than 1/2 inch), depending on the number of laminations and thickness of the pad. Edges of metal laminations shall have a cover of approximately 1/8 inch of elastomer. The top and bottom bearing surfaces shall each have an integral sealing rib approximately 1/8 inch in depth, in addition to the specified total thickness, and 3/16 inch in width around their peripheries. The bond between the elastomer and metal shall be such that failure shall occur in the elastomer and not between the elastomer and steel when tested for separation. Variations from specified dimensions for individual laminations shall not be more than those specified herein. The total thickness of the complete pad shall not vary more than ±1/8 inch.

D. Material having a nominal durometer hardness of 70 and 50 shall be used for nonlaminated pads and laminated pads, respectively. Test samples will be prepared from finished pads. Samples of each thickness will be taken from 2 full-size pads from each shipment of 300 pads or less, with 1 additional pad for each additional increment of 300 pads or fraction thereof. When tested using the ASTM methods designated, samples shall comply with the following physical requirements.

1. **Original Physical Properties:** Test results for tear resistance, tensile strength, and ultimate elongation shall not be more than 10 percent below the following specified value:

	Nominal Hardness 50	70
Min. tear resistance, ASTM D624, Die C (lb/in of thickness)	180	200
Hardness, ASTM D2240 (points)	50±5	70±5
Min. tensile strength, ASTM D412 (average psi of longitudinal and transverse)	2,500	2,500
Min. ultimate elongation (%)	400	300

The compressive deflection tested in accordance with ASTM D575, Method A, shall be as follows:

a. **Laminated Pads:** The maximum compression deflection shall be 5 and 7 percent of the total rubber thickness at loads of 500 and 800 pounds per square inch, respectively. The maximum shear resistance shall be 50 pounds per square inch of the plan area at 25 percent shear deformation at –20°F. Test pads shall be subjected to a compressive load of 1.5 times the maximum design load without visible damage to the bearing.

b. **Nonlaminated Pads:** When loaded within 300 to 800 pounds per square inch, material shall show a compressive deflection within 20 percent of that given in the charts of Method A, interpolating for actual measured hardness.

2. **Changes in Original Physical Properties:** When pads are oven aged 70 hours at 212°F in accordance with ASTM D573, changes shall not be more than the following:

Property	Value
Hardness (points change)	0 to +15
Tensile strength (% change)	±15
Ultimate elongation (% change)	-40

3. **Extreme Temperature Characteristics:** Compression set under constant deflection, ASTM D395, Method B, 22 hours at 212°F, shall not be more than 35 percent. With the low-temperature brittleness test, ASTM D746, breaks shall not occur above –20°F.

4. **Ozone Cracking Resistance:** Upon exposure to 100 parts per million of ozone in air by volume at a strain of 20 percent and a temperature of 100±2°F in a test otherwise in accordance with ASTM D1149, cracks shall not develop within 100 hours. Samples shall be wiped with solvent before the test to remove traces of surface impurities.

5. **Oil Swell:** The volume change shall not be more than +120 percent when tested in accordance with ASTM D471 with ASTM Oil No. 3, 70 hours at 212°F.

2.02 TFE BEARING SURFACES

(NOT USED)

2.03 PREFORMED FABRIC BEDDING MATERIAL

A. Material shall be composed of multiple layers of 8-ounce cotton duck impregnated and bound with high-quality natural rubber or its equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plys shall be such as to produce the specified thickness after compression and vulcanizing. Finished pads shall withstand compression loads perpendicular to the plane of the laminations of at least 10,000 pounds per square inch without a detrimental reduction in thickness or extrusion.

2.04 ANCHOR RODS

A. Anchor bolts shall be as specified in Section 05050, Metal Fastening.

2.05 PIPE SLEEVES AND COLLARS

A. Pipe sleeves and collars shall be cut from schedule 40 PVC plastic pipe meeting the requirements of ASTM D1785 unless otherwise noted on the Drawings.

PART 3 -- EXECUTION

3.01 STEEL PLATES, SHAPES, AND BARS

A. Unless galvanizing is indicated on the Drawings, items shall be painted in accordance with the Drawings and Section 09900, Painting.

B. If galvanizing is indicated on the Drawings, steel bearing assemblies for both structural steel beams and girders and prestressed concrete members shall be galvanized as specified in Section 05035, Galvanizing. Except for attachments of bearing plates to beams, all fabrication and welding of bearing plate assemblies shall be performed before the steel is galvanized. All joints of welded parts shall be sealed with weld material. Welds made for attaching bearing plates to beams or girders shall be cleaned and given 2 coats of zinc rich paint having a minimum total coating thickness of 3 mils.

3.02 BRONZE PLATES

(NOT USED)

3.03 COPPER-ALLOY PLATES

(NOT USED)

3.04 SELF-LUBRICATING PLATES

(NOT USED)

3.05 ELASTOMERIC PADS

A. Care shall be taken in fabricating pads and related metal parts so that effects detrimental to their proper performance, such as uneven bearing and excessive bulging, will not occur.

3.06 PLACEMENT OF BEARING PLATES AND PADS

A. Bearing areas shall be finished to a true level plane which shall not vary perceptibly from a straightedge placed in any direction across the area.

B. Bearing plates or pads shall be set level in exact position and shall have a uniform bearing over the entire area. Provision shall be made to keep plates or pads in the correct position during erection of beams or placement of concrete.

C. Elastomeric pads and other flexible bearing materials shall be placed directly on masonry surfaces finished to a roughness equivalent to that of a No. 36 to No. 46 grit. Pads, bearing areas, or bridge seats and metal bearing plates shall be thoroughly cleaned and free from oil, grease, and other foreign materials. Metal bearing plates or bottoms of prefabricated beams that are to bear on elastomeric pads shall be coated with epoxy and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit. Bearing areas shall be finished to equivalent roughness.

D. Metal bearing plates shall be bedded on seats as follows:

1. The seat bearing areas shall be thoroughly swabbed with approved paint, and three layers of duck, 12 to 15 ounce per square yard, shall be placed on it, each layer being thoroughly swabbed with paint on its top surface.

2. Superstructure shoes or pedestals shall be placed in position while paint is plastic. As an alternate to duct and paint, preformed fabric bedding material at least 1/8 inch in thickness may be used when called for on the Drawings or approved in writing by the Engineer.

3.07 PLACEMENT OF ANCHOR RODS

A. All necessary anchor rods and bolts (anchors) shall be accurately set either in the concrete as they are being placed, in formed holes, or in holes cored after the concrete has set. If set in the concrete, the rods and bolts shall be accurately positioned by means of templates and rigidly held in position while the concrete is being placed. Holes may be formed by inserting or casting in the fresh concrete oiled wooden plugs, metal pipe or plastic sleeves, or other approved devices, and withdrawing them after the concrete has partially set or left in place as indicated on the Drawing's or approved by the Engineer. Holes so formed shall be at least 3 inches in diameter or at least 2.5 times the diameter of the rod or bolt. If cored, holes shall be at least 2.5 times the diameter of the anchor used or as indicated on the Drawings. Equipment used for coring concrete shall have been approved by the Engineer. Impact tools will not be permitted. Reinforcing steel shall be placed to provide adequate space to core rod/bolt holes without cutting the reinforcing steel. For cored holes, anchor rods and bolts

shall be adequately held in place at the centroid of the hole or as specified on the Drawings by using approved pre-fabricated equalizers designed to allow grout to penetrate and fill the hole completely and spaced as approved by the Engineer.

B. During freezing conditions, anchor holes shall be protected from water accumulations at all times.

C. Anchors which are to be placed in holes of sufficient and specified diameter after the concrete has set shall be bonded to the concrete with a non-shrink high-strength Portland cement grout in accordance with Section 03600 – Grout or shall be adhesive anchors in accordance with Section 05050 - Metal Fastening. The type anchoring system and grout shall be as indicated on the Drawings. The grout or adhesive shall completely fill the holes. Anchors shall be tested for sufficient pull-out capacity as indicated in applicable sections of the Specifications or as indicated on the Drawings.

D. Anchors that are not designed to project through bearing plates shall be checked for proper projection above the masonry bearing area immediately prior to placement of bearing plates and beams. Nuts on anchor rods at expansion ends shall be adjusted to permit free movement of the span.

E. Angles for anchor assemblies to be attached to sides of concrete beams shall not be installed until beams have received their full dead load and supporting falsework has been removed.

- END OF SECTION -

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SECTION 07900

JOINT FILLERS, SEALANTS AND CAULKING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish labor, materials, equipment and appliances required for the complete execution of Work shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03250 - Concrete Accessories

B. Section 03290 - Joints in Concrete

C. Section 08800 - Glass and Glazing

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ASTM C-920 Elastomeric Joint Sealants

2. ASTM D-1056 Flexible Cellular Materials - Sponge or Expanded Rubber

3. SWRI Sealant and Caulking Guide Specification

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 – Submittals, submit the following:

1. Manufacturers literature and installation instructions.

2. Color samples of each type of sealant.

1.05 QUALITY ASSURANCE

A. Applicator shall be a company specializing in the installation of sealants with a minimum of five years experience.

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1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in unopened labeled packages.

B. Store materials in location protected from freezing or damages.

C. Reject and remove from the site materials within broken or damaged packaging.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Sealants

1. Type 1: Multi-component, non-sag, low-modulus polyurethane rubber sealant meeting ASTM C-920, Type M, Grade NS, Class 25, use NT, M, A, and O. Capable of withstanding 50% in extension or compression such as Sikaflex-2C NS/SL, Sika Corporation, or Sonolastic NP-2, Sonneborn, or DynaTrol II by Pecora Corporation.

2. Type 2: Single component polyurethane sealant meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, A, and O. Capable of withstanding 25% in extension or compression such as Sikaflex 1A by Sika Corporation, DynaTrol 1-XL by Pecora Corporation, or Sonolastic NP-1 by BASF Construction Chemicals.

3. Type 3: Single component, low-modulus moisture curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Capable of withstanding 50% extension and compression. Pecora 890 by Pecora Corporation, Sonolastic Omni Seal by BASF Construction Chemicals.

4. Type 4: Single component, mildew resistant, moisture-curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Pecora 898 by Pecora Corporation, Sonolastic Omni Plus by BASF Construction Chemicals.

5. Type 5: Single component, acrylic latex meeting ASTM C-834. AC-20+ Silicone by Pecora Corporation, Sonneborn Sonolac by BASF Construction Chemicals.

6. Type 6: High grade butyl sealant meeting Federal Specification TT-S-00-1657. BC-158 by Pecora Corporation or equal.

7. Type 7: Multi-component chemical resistant polysulfide sealant conforming to ASTM C-920, Type M, Grade NS, Class 25 such as Deck-O-Seal by W.R. Meadows, Tammsflex by DuraJoint Concrete Accessories, or Synthacalk GC2+ by Pecora Corporation.

8. Type 8: Nonsag, Multi Component, traffic grade polyurethane sealant meeting ASTM C920, Type 19, Grade NS, Class 25, use T, M, A, and O. DynaTread by Pecora Corporation, Sonolastic Ultra by BASF Construction Chemicals.

B. Primer: Non-staining primer recommended by sealant manufacturer for the substrates on this project.

C. Backer Rod: Closed cell foam, nonreactive with caulking materials, non-oily, and approved by the sealant manufacturer. Minimum density shall be 2.00 pounds per cubic foot. Use no asphalt or bitumen-impregnated fiber with sealants.

D. Joint Cleaner: Recommended by sealant or caulking compound manufacturer.

E. Bond breaker: Either polyethylene film or plastic tape as recommended by the sealant manufacturer.

F. Color: Where manufacturer's standard colors do not closely match materials being sealed, provide a custom color.

PART 3 -- EXECUTION

3.01 QUALITY CONTROL

A. Coordinate work with details shown on approved shop drawings prepared by other trades.

B. Verify conditions in the field.

C. Schedule work to follow closely the installation of other trades.

D. Apply sealants and related items in temperatures and dry conditions recommended by the manufacturers.

E. Do not paint sealant, unless recommended by sealant and paint manufacturer.

3.02 PREPARATION

A. Protect finished surfaces adjoining by using masking tape or other suitable materials.

B. Clean and prime joints before starting any caulking or sealing work.

C. Thoroughly clean joints and spaces of mortar and other foreign materials. Cleaning agent shall be Xylol or similar non-contaminating solvent to remove any film from metal surfaces. Masonry or concrete surfaces shall be brushed or air jet cleaned.

D. Joint Requirements

1. All joints and spaces to be sealed in exterior work shall be less than 1/2 inch deep and not less than 1/4 inch wide. If joints in masonry are less than that specified herein, the mortar shall be cut out to the required width and depth. All joints and spaces to receive sealant shall be completely prepared and thoroughly dry before installation of sealant.

2. Unless otherwise specified, joints and spaces which are open to a depth of 1/2 inch or greater shall be solidly filled with back-up material to within 1/4 inch of the surface. Back-up material shall be packed tightly and made continuous throughout the length of the joints. Bond breaker shall be applied as required. If joints are less than 1/4 inch deep, the back-up material may be omitted, a bond breaker substituted and the joint completely filled with sealant. The back-up material shall not project beyond the 1/4 inch depth of the open space in any joint. The following width-to-depth ratio table shall be adhered to, unless otherwise recommended by manufacturer.

	Sealant Depth	
Joint Width	Minimum	Maximum
¼ inch	1/4 inch	1/4 inch
Over 1/4 inch to 1/2 inch	1/4 inch	Equal to width
Over 1/2 inch to 1 inch	1/2 inch	Equal to width
Over 1 inch to 2 inch	1/2 inch	1/2 of width

3.03 APPLICATION

A. Exercise care before, during, and after installation so as not to damage any material by tearing or puncturing. All finished work shall be approved before covering with any other material or construction.

B. Apply sealant by an approved type of gun except where the use of a gun is not practicable, suitable hand tools shall be used. Avoid applying the compound to any surface outside of the joints or spaces to be sealed. Mask areas where required to prevent overlapping of sealant.

C. All joints shall be waterproof and weathertight.

D. Point sealed joints to make a slightly concave joint, the edges of which are flush with the surrounding surfaces. Exposed joints in the interior side of the door and other frames shall be neatly pointed flush or to match adjacent jointing work.

E. Adjacent materials which have been soiled shall be cleaned immediately and the work left in neat and clean condition.

F. Comply with sealant manufacturer's written instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

3.04 ADJUSTMENT AND CLEANING

A. Remove misplaced sealant compounds promptly using methods and materials recommended by the manufacturer, as the work progresses.

B. Allow sealants to cure and remove protective edging, of doors, louvers, saddles windows etc. as directed by the Engineer.

3.05 SCHEDULE

Schedule of Sealants

Application	Sealant	Color
Vertical and horizontal expansion and construction joints in concrete structures unless noted otherwise herein or on Drawings.	Type 1	To closely match adjacent surfaces or mortar and as selected by the Owner.
Vertical and horizontal joints bordered on both sides by masonry, precast concrete, natural stone or other porous building material, unless noted otherwise herein or on Drawings.	Type 2	To closely match adjacent surfaces or mortar and as selected by the Owner.
Vertical and horizontal joints bordered on both sides by painted metals, anodized aluminum, mill finished aluminum, PVC, glass or other non-porous building material.	Type 3	To closely match adjacent surfaces and as selected by the Owner.
Masonry expansion and control joints less than 1¼" wide.	Type 2	To closely match adjacent surfaces and as selected by the Owner.
Masonry expansion and control joints equal or greater than 1¼ inches wide and not to exceed 2”.	Type 1	To closely match adjacent surfaces and as selected by the Owner.
Interior – wood trim and finish joints.	Type 5	Color to be selected by Owner
Sanitary areas, joints in ceramic tile, around plumbing fixtures, countertops, and back splashes. See Note 1.	Type 4	To closely match adjacent surfaces and as selected by the Owner.
Perimeter sealing of doors, windows, louvers, piping, ducts, and electrical conduit. See Note 2.	Type 2 OR Type 3	To closely match adjacent surfaces and as selected by the Owner.
Below thresholds.	Type 6	Manufacturer's standard
Submerged in liquids. See Note 4.	Type 1	Manufacturer's standard
Submerged in liquids with high concentration of chlorine (> 2 ppm).	Type 7	Manufacturer’s standard
Horizontal Joints exposed to vehicular or pedestrian traffic.	Type 8	To closely match adjacent surfaces.

Application	Sealant	Color
Other joints indicated on the drawings or customarily sealed but not listed.	Type recommended by manufacturer	To closely match adjacent surfaces and as selected by the Owner.

Note 1. Sealant for Laboratory Countertop shall be as recommended by countertop manufacturer.

Note 2. Provide UL approved sealants for penetrations thru fire-rated walls and as specified in Section 07270.

Note 3. Sealants which will come in contact with potable water shall meet the requirements of NSF 61.

Note 4. Where sealant will be immersed in liquid chemicals verify compatibility prior to installation of sealant.

- END OF SECTION -

SECTION 09900

PAINTING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and Specified herein.

B. Section Includes:

1. Paint Materials

2. Shop Painting

3. Field Painting

a. Surface Preparation

b. Piping and Equipment Identification

c. Schedule of Colors

d. Work in Confined Spaces

e. OSHA Safety Colors

1.02 RELATED SECTIONS

A. Section 15030 - Piping and Equipment Identification Systems

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of these specifications the Work shall conform to the applicable requirements of the following documents:

1. SSPC – The Society for Protective Coatings Standards

a.	SSPC-Vis 1	Pictorial Surface Preparation Standards for Painting Steel Structures
b.	SSPC-SP2	Hand Tool Cleaning
c.	SSPC-SP3	Power Tool Cleaning
d.	SSPC-SP5	White Metal Blast Cleaning

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e. SSPC-SP6 Commercial Blast Cleaning

f. SSPC-SP10 Near-White Metal Blast

g. SSPC-SP13/NACE6 Surface Preparation of Concrete

2. NACE - National Association of Corrosion Engineers

3. ASTM D1737 - Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus

4. ASTM B117 - Method of Salt Spray (Fog) Testing

5. ASTM D4060 - Test Method for Abrasion Resistance of Organic Coating by the Taber Abraser

6. ASTM D3359 - Method for Measuring Adhesion by Tape Test

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 - Submittals, submit the following:

1. Manufacturer's literature and Material Safety Data Sheets for each product.

2. Painting schedule identifying surface preparation and paint systems proposed. Cross-reference with Tables 9-1 and 9-2. Provide the name of the paint manufacturer, and name, address, and telephone number of manufacturer's representative who will inspect the work. Submit schedule for approval as soon as possible following the Award of Contract, so approved schedule may be used to identify colors and specify shop paint systems for fabricated items.

1.05 SYSTEM DESCRIPTION

A. Work shall include surface preparation, paint application, inspection of painted surfaces and corrective action required, protection of adjacent surfaces, cleanup and appurtenant work required for the proper painting of all surfaces to be painted. Surfaces to be painted are designated within the Painting Schedule and may include new and existing piping, miscellaneous metals, equipment, buildings, exterior fiberglass, exposed electrical conduit and appurtenance.

B. Perform Work in strict accordance with manufacturer's published recommendations and instructions, unless the Engineer stipulates that deviations will be for the benefit of the project.

C. Paint surfaces which are customarily painted, whether indicated to be painted or not, with painting system applied to similar surfaces, areas and environments, and as approved by Engineer.

D. Piping and equipment shall receive color coding and identification. Equipment shall be the same color as the piping system.

1.06 QUALITY ASSURANCE

A. Painting operations shall be accomplished by skilled craftsman and licensed by the state to perform painting work.

B. Provide a letter indicating that the painting applicator has five years of experience, and 5 references which show previously successful application of the specified or comparable painting systems. Include the name, address, and the telephone number for the Owner of each installation for which the painting applicator provided services.

1.07 STORAGE AND DELIVERY

A. Bring materials to the job site in the original sealed and labeled containers.

B. Container label to include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.

C. Store paint materials at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

PART 2 -- MATERIALS

2.01 GENERAL INFORMATION

A. The term "paint" is defined as both paints and coatings including emulsions, enamels, stains, varnishes, sealers, and other coatings whether organic or inorganic and whether used as prime, intermediate, or finish coats.

B. Purchase paint from an approved manufacturer. Manufacturer shall assign a representative to inspect application of their product both in the shop and field. The manufacturer's representative shall submit a report to the Engineer at the completion the Work identifying products used and verifying that surfaces were properly prepared, products were properly applied, and the paint systems were proper for the exposure and service.

C. Provide primers and intermediate coats produced by same manufacturer as finish coat. Use only thinners approved by paint manufacturer, and only within manufacturer's recommended limits.

D. Ensure compatibility of total paint system for each substrate. Test shop primed equipment delivered to the site for compatibility with final paint system. Provide an acceptable barrier coat or totally remove shop applied paint system when incompatible with system specified, and repaint with specified paint system.

E. Use painting materials suitable for the intended use and recommended by paint manufacturer for the intended use.

F. Require that personnel perform work in strict accordance with the latest requirements of OSHA Safety and Health Standards for construction. Meet or exceed requirements of regulatory agencies having jurisdiction and the manufacturer's published instructions and recommendations. Maintain a copy of all Material Safety Data Sheets at the job site of each product being used prior to commencement of work. Provide and require that personnel use protective and safety equipment in or about the project site. Provide respiratory devices, eye and face protection, ventilation, ear protection, illumination and other safety devices required to provide a safe work environment.

2.02 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:

1. Tnemec Company Inc.

2. Ameron

3. CARBOLINE

4. Sherwin-Williams

5. International

PART 3 -- EXECUTION

3.01 SHOP PAINTING

A. Shop prime fabricated steel and equipment with at least one shop coat of prime paint compatible with finish paint system specified. Prepare surface to be shop painted in strict accordance with paint manufacturer's recommendations and as specified. Finish coats may be shop applied, if approved by the Engineer. Package, store and protect shop painted items until they are incorporated into Work. Repair painted surfaces damaged during handling, transporting, storage, or installation to provide a painting system equal to the original painting received at the shop.

B. Identify surface preparation and shop paints on Shop Drawings. Verify compatibility with field applied paints.

3.02 SURFACE PREPARATION

A. General

1. Surfaces to be painted shall be clean and dry, and free of dust, rust, scale, and foreign matter. No solvent cleaning, power or hand tool cleaning shall be permitted unless approved by the Engineer.

2. Protect or remove, during painting operations, hardware, accessories, machined surfaces, nameplates, lighting fixtures, and similar items not intended to be painted prior to cleaning and painting. Reposition items removed upon completion of painting operations.

3. Examine surfaces to be coated to determine that surfaces are suitable for specified surface preparation and painting. Report to Engineer surfaces found to be unsuitable in writing. Do not start surface preparation until unsuitable surfaces have been corrected. Starting surface preparation precludes subsequent claim that such surfaces were unsuitable for the specified surface preparation or painting.

4. Surface preparation shall be in accordance with specifications and manufacturer's recommendations. Provide additional surface preparation, and fill coats where manufacturer recommends additional surface preparation, in addition to requirements of specification.

5. Touch-up shop or field applied coatings damaged by surface preparation or any other activity, with the same shop or field applied coating; even to the extent of applying an entire coat when required to correct damage prior to application of the next coating. Touch-up coats are in addition to the specified applied systems, and not considered a field coat.

6. Protect motors and other equipment during blasting operation to ensure blasting material is not blown into motors or other equipment. Inspect motors and other equipment after blasting operations and certify that no damage occurred, or where damage occurred, the proper remedial action was taken.

7. Field paint shop painted equipment in compliance with Color Coding and as approved by Engineer.

B. Metal Surface Preparation

1. Conform to current The Society for Protective Coatings Standards (SSPC) Specifications for metal surface preparation. Use SSPC-Vis-1 pictorial standards or NACE visual standards TM-01-70 or TM-01-75 to determine cleanliness of abrasive blast cleaned steel.

2. Perform blast cleaning operations for metal when following conditions exist:

   a. Moisture is not present on the surface.

   b. Relative humidity is below 80%.

   c. Ambient and surface temperatures are 5°F or greater than the dew point temperature.

   d. Painting or drying of paint is not being performed in the area.

   e. Equipment is in good operating condition.

f. Proper ventilation, illumination, and other safety procedures and equipment are being provided and followed.

3. Sandblast ferrous metals to be shop primed, or component mechanical equipment in accordance with SSPC-SP5, White Metal Blast.

4. Sandblast field prepared ferrous metals in accordance with SSPC-SP10, Near White Metal Blast, where metal is to be submerged, in a corrosive environment, or in severe service.

5. Sandblast field prepared ferrous metals in accordance with SSPC-SP6 Commercial Blast, where metal is to be used in mild or moderate service, or non-corrosive environment.

6. Clean nonferrous metals, copper, or galvanized metal surfaces in accordance to SSPC-SP1, Solvent Cleaning, or give one coat of metal passivator or metal conditioner compatible with the complete paint system.

7. Prime cleaned metals immediately after cleaning to prevent rusting.

8. Clean rusted metals down to bright metal by sandblasting and immediately field primed.

C. Concrete Surface Preparation

1. Cure concrete a minimum of 30 days before surface preparation, and painting begins.

2. Test concrete for moisture content, pH and salts using test method recommended by the paint manufacturer. Do not begin surface preparation, or painting until moisture content is acceptable to manufacturer.

3. Prepare concrete surfaces to receive coatings in accordance with SSPC-13 – Concrete Surface Preparation. Remove contaminants, open bugholes, surface voids, air pockets, and other subsurface irregularities using blasting or grinding. Do not expose underlying aggregate. Use dry, oil-free air for blasting operations. Surface texture after blasting shall achieve profile as required by manufacturer or where not defined by manufacturer similar to that of medium grit sandpaper. Remove residual abrasives, dust, and loose particles by vacuuming or other approved method.

4. Surface defects, such as hollow areas, bugholes, honeycombs, and voids shall be filled with polymeric filler compatible with painting system. Complete fill coats may be used in addition to specified painting system and as approved by the Engineer. Fins, form marks, and all protrusions or rough edges shall be removed.

5. Repair existing concrete surfaces which are deteriorated to the point that surface preparation exposes aggregate with fill coats or patching mortar as recommended by paint manufacturer and as directed by the Engineer.

6. Clean concrete of all dust, form oils, curing compounds, oil, tar, laitance, efflorescence, loose mortar, and other foreign materials before paints are applied.

D. Previously-Painted Surfaces

1. Totally remove existing paint when: surface is to be submerged in a severe environment, paint is less than 75% intact, brittle, eroded or has underfilm rusting.

2. Surfaces which are greater than 75% intact require removal of failed paints and then spot primed. Spot priming is in addition to coats specified.

3. Remove surface contamination such as oil, grease, loose paint, mill scale, dirt, foreign matter, rust, mold, mildew, mortar, efflorescence, and sealers.

4. Clean and dull glossy surfaces prior to painting in accordance with the manufacturer's recommendations.

5. Check existing paints for compatibility with new paint system. If incompatible, totally remove existing paint system or apply a barrier coat recommended by the paint manufacturer. Remove existing paints of undetermined origin. Prepare a test patch of approximately 3 square feet over existing paint. Allow test patch to dry thoroughly and test for adhesion. If proper adhesion is not achieved remove existing paint and repaint.

3.03 APPLICATION OF PAINT

A. Apply paint by experienced painters with brushes or other applicators approved by the Engineer, and paint manufacturer.

B. Apply paint without runs, sags, thin spots, or unacceptable marks.

C. Apply at rate specified by the manufacturer to achieve at least the minimum dry mil thickness specified. Apply additional coats, if necessary, to obtain thickness.

D. Special attention shall be given to nuts, bolts, edges, angles, flanges, etc., where insufficient film thicknesses are likely. Stripe paint prior to applying prime coat. Stripe painting shall be in addition to coats specified.

E. Perform thinning in strict accordance with the manufacturer's instructions, and with the full knowledge and approval of the Engineer and paint manufacturer.

F. Allow paint to dry a minimum of twenty-four hours between application of any two coats of paint on a particular surface, unless shorter time periods are a requirement by the manufacturer. Longer drying times may be required for abnormal conditions as defined by the Engineer and paint manufacturer. Do not exceed manufacturer's recommended drying time between coats.

G. Suspend painting when any of the following conditions exist:

1. Rainy or excessively damp weather.

2. Relative humidity exceeds 85%.

3. General air temperature cannot be maintained at 50°F or above through the drying period, except on approval by the Engineer and paint manufacturer.

4. Relative humidity will exceed 85% or air temperature will drop below 40°F within 18 hours after application of paint.

5. Surface temperature of item is within 5 degrees of dewpoint.

6. Dew or moisture condensation are anticipated.

7. Surface temperature exceeds the manufacturer's recommendations.

3.04 INSPECTION

A. Each field coat of paint will be inspected and approved by the Engineer or his authorized representative before succeeding coat is applied. Tint successive coats so that no two coats for a given surface are exactly the same color. Tick-mark surfaces to receive black paint in white between coats.

B. Use magnetic dry film thickness gauges and wet fiber thickness gauges for quality control. Furnish magnetic dry film thickness gauge for use by the Engineer.

C. Coatings shall pass a holiday detector test.

D. Determination of Film Thickness: Randomly selected areas, each of at least 107.5 contiguous square feet, totaling at least 5% of the entire control area shall be tested. Within this area, at least 5 squares, each of 7.75 square inches, shall be randomly selected. Three readings shall be taken in each square, from which the mean film thickness shall be calculated. No more than 20 percent of the mean film thickness measurements shall be below the specified thickness. No single measurement shall be below 80 percent of the specified film thickness. Total dry film thickness greater than twice the specified film thickness shall not be acceptable. Areas where the measured dry film thickness exceeds twice that specified shall be completely redone unless otherwise approved by the Engineer. When measured dry film thickness is less than that specified additional coats shall be applied as required.

E. Holiday Testing: Holiday test painted ferrous metal surfaces which will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures. Mark areas which contain holidays. Repair or repaint in accordance with paint manufacturer's printed instructions and retest.

1. Dry Film Thickness Exceeding 20 Mils: For surfaces having a total dry film thickness exceeding 20 mils: Pulse-type holiday detector such as Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.

2. Dry Film Thickness of 20 Mils or Less: For surfaces having a total dry film thickness of 20 mils or less: Tinker & Rasor Model M1 non-destructive type holiday detector, K-D Bird Dog, shall be used. The unit shall operate at less than 75-volts. For thicknesses between 10 and 20 mils, a non-sudsing type wetting agent, such as Kodak Photo-Flow, shall be added to the water prior to wetting the detector sponge.

F. Paint manufacturer or his representative shall provide their services as required by the Engineer. Services shall include, but not be limited to, inspecting existing paint, determination of best means of surface preparation, inspection of completed work, and final inspection of painted work 11 months after the job is completed.

3.05 PROTECTION OF ADJACENT PAINT AND FINISHED SURFACES

A. Use covers, masking tape, other method when protection is necessary, or requested by Owner or Engineer. Remove unwanted paint carefully without damage to finished paint or surface. If damage does occur, repair the entire surface adjacent to and including the damaged area without visible lapmarks and without additional cost to the Owner.

B. Take all necessary precautions to contain dispersion of sandblasting debris and paint to the limits of the work. Take into account the effect of wind and other factors which may cause dispersion of the sandblasting debris and paint. Suspend painting operations when sanding debris or paint cannot be properly confined. Assume all responsibilities and cost associated with damage to adjacent structures, vehicles, or surfaces caused by the surface preparation and painting operations.

3.07 SCHEDULE OF COLORS

A. Match colors onsite. Colors which are not indicated shall be selected from the manufacturer's full range of colors by the Engineer. No variation shall be made in colors without the Engineer's approval. Color names and numbers shall be identified according to the appropriate color chart issued by the manufacturer of the particular product in question.

3.08 WORK IN CONFINED SPACES

A. Provide and maintain safe working conditions for all employees. Supply fresh air continuously to confined spaces through the combined use of existing openings, forced-draft fans and temporary ducts to the outside, or direct air supply to individual workers. Exhaust paint fumes to the outside from the lowest level in the contained space. Provide explosion-proof electrical fans, if in contact with fumes. No smoking or open fires will be permitted in, or near, confined spaces where painting is being done. Follow OSHA, state and local regulations at all times.

3.09 OSHA SAFETY COLORS

A. Paint wall around wall-mounted breathing or fire apparatus with the appropriate safety red color; area not exceed 2-feet wide by 3-feet high, unless apparatus covers the area. Fire apparatus include fire hoses, extinguisher, and hydrants.

B. Paint hazardous areas and objects in accordance with OSHA regulations.

TABLE 9-1
PAINTING SCHEDULE

SURFACE	APPLICATION	PAINTING SYSTEM & NO. OF COATS	PRODUCT REFERENCE (TABLE 9.2)	TOTAL MIN. DRY FILM THICKNESS (MILS)
Concrete and Masonry				
Submerged wastewater	Water retaining side of new wall surfaces where opposite side of wall is interior and dry and where indicated "epoxy waterproofing" on drawing	2 coats high solids epoxy Provide filler as required and recommended by manufacturer	119	6-10/coat
Metals				
Interior and exterior nonsubmerged (gloss)	All new blowers, pumps, motors and mechanical equipment, piping, etc.	1 coat epoxy polyamide primer 1 coat epoxy polyamide 1 coat aliphatic polyurethane	104 102 115	4-6 4-6 3-5
Interior insulated		1 coat acrylic latex	103	4
Submerged Wastewater		2 coats high solids epoxy	119	8-10/coat
Steel doors, windows and door frames, steel stairs, monorails, structural steel, misc. metals (steel)		1 coat epoxy polyamide 1 coat aliphatic polyurethane	102 115	5-8 3-4
Aluminum surfaces in contact with concrete		2 coats coal tar	107	26
Shop Primed Structural Steel	Pre-Engineered Buildings	1 barrier coat 1 coat epoxy 1 coat epoxy	113 114 120	2-3 3-4 3-4
Other				
PVC Piping		1 coat epoxy polyamide 1 coat aliphatic polyurethane	102 115	5-8 3-4

1. Painting manufacturer shall verify compatibility of containment liner and chemical to be contained. Where incompatible substitute a compatible coating system.

TABLE 9-2

PRODUCT LISTING

REF.	SYSTEM	PURPOSE	PRODUCT			
			Tnemec Series	PPG/AMERON	CARBOLINE	Sherwin-Williams
101	Acrylic filler	Primer-sealer	130-6601	BLOXFIL 4000	Sanitile 100	Cement-Plex 875
102	Epoxy polyamide	Finish coat semi-gloss or gloss	N69	AMERLOCK 2	Carboguard 890	Dura-Plate 235
103	Acrylic latex	Sealer	1028/1029	PITT TECH PLUS	Carbocrylic 3359DTM	DTM Acrylic Primer/Finish
104	Epoxy Polyamide – metal	Primer	66	AMERCOAT 385	Carboguard 893SG	Macropoxy 646
105	Epoxy	Primer/Finish	20	AMERLOCK 2	Carboguard 561/56LT	Macropoxy 646 PW
106	Coal tar epoxy	Finish high-coat build	46H-413	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
107	Coal tar	Sealer	46-465	AMERCOAT 78HB	Bitumastic 300M	Hi-Mil Sher Tar Epoxy
108	Alkyd-medium oil	Finish coat	2H	DEVGUARD 4308	Carbocoat 8215	Industrial Enamel
109	Alkyd-long oil	Finish coat	1029	DEVGUARD 4308	Carbocoat 8215	Industrial Enamel
110	Epoxy polyamide	Primer	66-1211	AMERCOAT 385	Carboguard 893SG	Macropoxy 646
112	Epoxy polyamide	Sealer	66-1211	AMERCOAT 385	Carboguard 893SG	Macropoxy 920 Pre-Prime
113	Urethane	Barrier coat	530	AMERLOCK SEALER	Rustbond	--
114	Polyamine Epoxy	Intermediate coat	27	AMERLOCK 385	Carboguard 893SG	--
115	Aliphatic Polyurethane	Finish coat	1074 or 1075	AMERCOAT 450 HS	Carbothane 134HG	Acrolon 218HS
116	Acrylic epoxy	Finish coat	113 or 114	AQUAPON WB	Sanitile 255	Water-Based Catalyzed Epoxy
117	Epoxy block filler	Sealer	1254	AMERLOCK 114	Sanitile 600	Kem Cati-Coat HS Epoxy Filler
118	Catalyzed epoxy	Finish coat	84	AMERLOCK 2/400	Carboguard 890	Macropoxy 646
119	High solids epoxy	Finish coat	104	AMERLOCK 400	Carboguard 890	Dura-Plate 235
120	Epoxy	Top coat	N69	AMERLOCK 2/400	Carboguard 890	--

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SECTION 10400

IDENTIFYING DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all labor, materials, equipment and appliances required for the complete execution of the Work as shown on the Drawings and specified herein.

B. Principal items of work include:

1. Plastic engraved door and informational signs as indicated on the Drawings.

2. Safety signs

1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 - Submittals, submit the following:

1. Color and finish samples for all nameplates, signs and building name letters.

2. Shop Drawings shall include, but not be limited to:

a. Complete details for all signs and building name letters giving sizes and styles of lettering and colors.

b. Complete schedules for all nameplates, signs, and building name letters giving location, message, letter, size, color, and method of attachment.

c. Details of fabrication and attachment of all items.

1.03 DELIVERY, STORAGE AND HANDLING

A. Deliver all materials in unopened, unbroken and undamaged original packaging bearing the manufacturer's label and identification for installation.

B. Handle all materials with care to prevent defacement of any nature.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:

111512BR

1. Andco Industries Corporation

2. Innerface Architectural Signage Incorporated

3. Environmental Sign Systems

2.02 MATERIALS

A. Signs

1. Interior signs shall be self extinguishing plastic with raised letters meeting the requirements of the American with Disabilities Act of 1990; total thickness minimum of 0.125 inch; rounded corners.

2. Exterior signs shall be aluminum with vinyl lettering and numbering.

B. Character size and style shall be 3/4 inch high minimum upper case Helvetica. Spacing and proportions of letters shall be in strict accordance with the Americans with Disabilities Act of 1990.

C. Colors shall be as selected by the Owner from the manufacturer standard colors.

D. Materials shall be suitable for exterior or interior exposure as applicable.

2.03 ACCESSORIES

A. Mounting Hardware: Stainless steel screws.

B. Tape Adhesive: Double sided tape, permanent adhesive.

2.04 FABRICATION

A. All items specified herein to be factory fabricated to the extent practicable.

B. Provide all attachments and anchors necessary for concealed installments for door numbers, room name plates, and bulletin boards.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All materials specified herein shall be installed in compliance with the approved manufacturer's printed specifications. Mounting devices, bolts, screws, nuts and the like shall be of high strength aluminum or stainless steel. The final location of each sign shall be as determined by the Engineer.

B. Plastic door numbers and room name plates shall be attached stainless steel oval Phillips head screw at each corner.

1. Submit a schedule of door numbers and name plates to the Engineer for approval.

2. Install door and name plates after final field finish has been applied and thoroughly dried.

3.02 ADJUSTMENT AND CLEANING

A. After completion of project, remove all protective devices, touch up as necessary and clean all exposed surfaces with a mild solution of detergent and warm water. Leave all surfaces in a neat and clean condition.

3.03 SCHEDULES

A. CAUTION SIGNS shall have a yellow background with the word CAUTION 2 inches high with white letters and black background centered above wording below in black letters. Each sign shall be provided with pictogram showing figure in compliance with sign (i.e. a figure wearing glasses)

Wording	**Size**	**Quantity**
EAR PROTECTION MUST BE WORN IN THIS AREA	7x17	4
NON-POTABLE WATER – DO NOT DRINK	7X17	2

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SECTION 11000

EQUIPMENT GENERAL PROVISIONS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in acceptable operation all mechanical equipment and all necessary accessories as specified herein, as shown on the Drawings, and as required for a complete and operable system.

B. The mechanical equipment shall be provided complete with all accessories, special tools, spare parts, mountings, and other appurtenances as specified, and as may be required for a complete and operating installation.

C. It is the intent of these Specifications that the Contractor shall provide the Owner complete and operational equipment/systems. To this end, it is the responsibility of the Contractor to coordinate all interfaces with related mechanical, structural, electrical, instrumentation and control work and to provide necessary ancillary items such as controls, wiring, etc., to make each piece of equipment operational as intended by the Specifications.

D. The complete installation shall be free from excessive vibration, cavitation, noise, and oil or water leaks.

E. The requirements of this section shall apply to equipment furnished under Divisions 11, 13, 14, and 15.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. All equipment, materials, and installations shall conform to the requirements of the most recent editions with latest revisions, supplements, and amendments of the specifications, codes, and standards listed in Section 01090, Reference Standards.

1.03 SHOP DRAWINGS

A. Shop Drawings shall be submitted to the Engineer for all equipment in accordance with Section 01300, Submittals and shall include the following information in addition to the requirements of Section 01300, Submittals:

1. Performance characteristics and descriptive data.

2. Detailed equipment dimensional drawings and setting plans.

3. General lifting, erection, installation, and adjustment instructions, and recommendations.

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4. Complete information regarding location, type, size, and length of all field welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society. Special conditions shall be fully explained by notes and details.

5. The total uncrated weight of the equipment plus the approximate weight of shipped materials. Support locations and loads that will be transmitted to bases and foundations. Exact size, placement, and embedment requirements of all anchor bolts.

6. Details on materials of construction of all components including applicable ASTM designations.

7. Information on bearing types and bearing life.

8. Gear box design and performance criteria and AGMA service factor.

9. Piping schematics.

10. Motor data sheet indicating motor horsepower; enclosure type; voltage; insulation class; temperature rise and results of dielectric tests; service-rating; rotative speed; motor speed-torque relationship; efficiency and power factor at ½, ¾, and full load; slip at full load; running, full load, and locked rotor current values; and safe running time-current curves.

11. Equipment and motor protective device details. Connection diagrams for motor and all protective devices.

12. Equipment shop coating systems, interior and exterior.

13. Panel layout drawings, schematic wiring diagrams, and component product data sheets for control panels.

14. A list of spare parts and special tools to be provided.

15. Any additional information required to show conformance with the equipment specifications.

16. Warranty documentation including statement of duration of warranty period and contact phone numbers and addresses for warranty issues.

1.04 OPERATION AND MAINTENANCE INSTRUCTION/MANUALS

A. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01300, Submittals.

B. O&M manuals shall include instructions, equipment ratings, technical bulletins, and any other printed matter such as wiring diagrams and schematics, prints or drawings, containing full information required for the proper operation, maintenance, and repair of the equipment. Included in this submission shall be a spare parts diagram, complete spare parts list, bill of materials, OEM part numbers and manufacturer's catalog information of all equipment components.

C. Each set of instructions shall be bound together in appropriate three-ring binders with a detailed Table of Contents..

D. Written operation and maintenance instructions shall be required for all equipment items supplied for this project. The amount of detail shall be commensurate with the complexity of the equipment item.

E. Information not applicable to the specific piece of equipment installed on this project shall be struck from the submission.

F. Information provided shall include a source of replacement parts and names of service representatives, including address and telephone number.

G. Extensive pictorial cuts of equipment are required for operator reference in servicing.

H. When written instructions include Shop Drawings and other information previously reviewed by the Engineer, only those editions thereof which were approved by the Engineer, and which accurately depict the equipment installed, shall be incorporated in the instructions.

1.05 GENERAL INFORMATION AND DESCRIPTION

A. All parts of the equipment furnished shall, be designed and constructed for the maximum stresses occurring during fabrication, transportation, installation, testing, and all conditions of operation. All materials shall be new, and both workmanship and materials shall be entirely suitable for the service to which the units are to be subjected and shall conform to all applicable sections of these Specifications.

B. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these Specifications.

C. Equipment and appurtenances shall be designed in conformity with ASTM, ASME, AIEE, NEMA, and other generally accepted applicable standards.

D. All bearings and moving parts shall be adequately protected by bushings or other approved means against wear, and provision shall be made for accessible lubrication by extending lubrication lines and fittings to approximately 30 inches above finished floor elevation.

E. Details shall be designed for appearance as well as utility. Protruding members, joints, corners, gear covers, etc., shall be finished in appearance. All exposed welds on machinery shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.

F. Machinery parts shall conform within allowable tolerances to the dimensions shown on the working drawings.

G. All machinery and equipment shall be safeguarded in accordance with the safety codes of the USA and the State in which the project is located.

H. All rotating shafts, couplings, or other moving pieces of equipment shall be provided with suitable protective guards of sheet metal or wire mesh, neatly and rigidly supported. Guards shall be removable as required to provide access for repairs.

I. All equipment greater than 100 pounds shall have lifting lugs, eyebolts, etc., for ease of lifting, without damage or undue stress exerted on its components.

J. All manufactured items provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products. .

1.06 EQUIPMENT WARRANTIES

A. Warranty requirements may be added to or modified in the individual equipment specifications.

B. The equipment furnished under this Contract shall be guaranteed to be free from defects in workmanship, design and/or materials for a period of two (2) years unless otherwise specified in the individual equipment specifications. The period of such warranties shall start on the date the particular equipment is placed in use by the Owner with corresponding start-up certification provided by the manufacturer's technical representative as specified herein, provided that the equipment demonstrates satisfactory performance during the fourteen day operational period after the equipment startup. If the equipment does not perform satisfactorily during the fourteen day operational period, the start of the warranty period will be delayed until the equipment demonstrates proper operation. The Equipment Supplier shall repair or replace without charge to the Owner any part of equipment which is defective or showing undue wear within the guarantee period, or replace the equipment with new equipment if the mechanical performance is unsatisfactory; furnishing all parts, materials, labor, etc., necessary to return the equipment to its specified performance level.

C. The Contractor shall provide an equipment warranty log book prepared specifically for this project and submit two (2) copies of the document to the Engineer prior to final payment. The equipment warranty log book shall include a summary listing of all equipment warranties provided, date received, and start date and end date of warranty period. A copy of each equipment warranty and equipment start-up certification shall also be provided in the document.

D. The Equipment Supplier shall guarantee to the Owner that all equipment offered under these specifications, or that any process resulting from the use of such equipment in the manner stated is not the subject of patent litigation, and that he has not knowingly offered equipment, the installation or use of which is likely to result in a patent controversy, in which the Owner as user is likely to be made the defendant.

Where patent infringements are likely to occur, each Equipment Supplier shall submit, as a part of his bid, license arrangements between himself, or the manufacturer of the equipment offered, and the patent owner or the controller of the patent, which will permit the use in the specified manner of such mechanical equipment as he may be bidding.

Each Equipment Supplier, by submitting his bid, agrees to hold and save the Owner and Engineer or its officers, agents, servants, and employees harmless from liability of any nature or kind, including cost and expenses for, or on account of, any patented or unpatented invention, process, article, or appliance manufactured or used in the performance of the work under this contract, including the use of the same by the Owner.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The materials covered by these Specifications are intended to be equipment of proven reliability, and as manufactured by reputable manufacturers having experience in the production of such equipment. The Contractor shall, upon request of the Engineer, furnish the names of not less than 5 successful installations of the manufacturer's equipment of the same size and model of that offered under this contract. The equipment furnished shall be designed, constructed, and installed in accordance with the industry accepted practices and shall operate satisfactorily when installed as shown on the Drawings and operated per manufacturer's recommendations.

2.02 ANCHORS AND SUPPORTS

A. The Contractor shall furnish, install, and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of the devices included in the equipment specified. Working Drawings for installation shall be furnished by the equipment manufacturer, and suitable templates shall be used by the Contractor when required in the detailed equipment Specifications.

B. Anchor bolts and fasteners shall be furnished in accordance with Section 05050, Metal Fastening, and with the individual equipment Specifications. All anchor bolts shall be a minimum of 1/2-inch diameter. All anchor bolts, handrail bolts, washers, clips, clamps, and fasteners of any type shall be constructed of 316 stainless steel, unless otherwise specified the individual equipment Specifications.

C. The Contractor shall provide all concrete pads or pedestals required for equipment furnished. All concrete equipment pads shall be a minimum of 6” high, unless otherwise shown on the Drawings and shall be doweled.

D. Pipe sleeves or other means of adjusting anchor bolts shall be provided where indicated or required. Equipment shall be leveled by first using sitting nuts on the anchor bolts, and then filling the space between the equipment base and concrete pedestal with non-shrink grout, unless alternate methods are recommended by the manufacturer and are acceptable to the Engineer (such as shim leveling pumps, or chemical grout). Non-shrink grout shall be as specified in Section 03600, Grout.

2.03 STRUCTURAL STEEL

A. All materials shall conform to applicable provisions of the AISC Specifications for the design and fabrication of structural steel, and to pertinent ASTM Standard Specifications.

2.04 DISSIMILAR METALS

A. All dissimilar metals shall be properly isolated to the satisfaction of the Engineer.

2.05 GALVANIZING

A. Where required by the equipment specifications, galvanizing shall be performed in accordance with Section 05035, Galvanizing.

2.06 STANDARDIZATION OF GREASE FITTINGS

A. The grease fittings on all mechanical equipment shall be such that they can be serviced with a single type of grease gun. Fittings shall be “Zerk” type.

2.07 ELECTRICAL REQUIREMENTS

A. All electrical equipment and appurtenances, including but not limited to motors, panels, conduit and wiring, etc., specified in the equipment specifications shall comply with the applicable requirements of the Division 16 specifications and the latest National Electric Code.

B. Motors shall conform to the applicable requirements of Section 15170, Electric Motors. Medium voltage motors shall conform to the applicable requirements of Section 15171, Medium Voltage Electric Motors.

C. In the individual equipment specifications, specified motor horsepower is intended to be the minimum size motor to be provided. If a larger motor is required to meet the specified operating conditions and performance requirements, the Contractor shall furnish the larger sized motor and shall upgrade the electrical service (conduit, wires, starters, etc.) at no additional cost to the Owner.

D. Where variable frequency drives (VFDs) are specified, the Contractor shall be responsible for coordinating between equipment supplier and VFD supplier to ensure a complete and operational system. VFDs shall be furnished under Division 16 and shall be as specified in Section 16495, Variable Frequency Drive Systems.

E. Motor starters and controls shall be furnished and installed under Division 16 and Division 17 unless otherwise specified in the individual pump specifications.

2.08 ACCESSORIES, SPARE PARTS, AND SPECIAL TOOLS

A. Spare parts for equipment shall be furnished where indicated in the equipment Specifications or where recommended by the equipment manufacturer.

B. Spare parts shall be identical and interchangeable with original parts.

C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

D. Painting requirements for spare parts shall be identical to those for original, installed parts. Where no painting or protective coating is specified, suitable provisions shall be made to protect against corrosion.

E. Spare parts shall be delivered at the same time as the equipment to which they pertain. Spare parts shall be stored separately in a locked area, maintained by the Contractor, and shall be turned over to the Owner in a group prior to substantial completion. All of these materials shall be properly packed, labeled, and stored where directed by the Owner and Engineer.

F. The Contractor shall furnish all special tools necessary to operate, disassemble, service, repair, and adjust the equipment in accordance with the manufacturers operation and maintenance manual.

G. The Contractor shall furnish a one year supply of all recommended lubricating oils and greases. The manufacturer shall submit a list of at least four manufacturer's standard lubricants which may be used interchangeably for each type of lubricant required. All of these materials shall be properly packed, labeled and stored where directed by the Engineer.

2.09 EQUIPMENT IDENTIFICATION

A. All mechanical equipment shall be provided with a substantial stainless steel nameplate, mechanically fastened with stainless steel hardware in a conspicuous place, and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data.

B. Each pump and other piece of mechanical equipment shall also be identified as to name and number by a suitable laminated plastic or stainless steel nameplate mechanically fastened with stainless steel hardware; for example, "Raw Water Pump #1". Coordinate name and number with same on remotely located controls, control panel, and other related equipment.

C. Nameplates shall not be painted over.

PART 3 -- EXECUTION

3.01 SHOP TESTING

A. All equipment shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and that it will operate in the manner specified or implied.

B. No equipment shall be shipped to the project until the Engineer has been furnished a certified copy of test results and has notified the Contractor, in writing, that the results of such tests are acceptable.

C. Five (5) certified copies of the manufacturer's actual test data and interpreted results thereof shall be forwarded to the Engineer for review.

D. If required by the individual equipment Specifications, arrangements shall be made for the Owner/Engineer to witness performance tests in the manufacturer's shop. The Engineer shall be notified ten working days before shop testing commences. Expenses are to be paid by Owner.

E. Shop testing of electric motors shall be in accordance with applicable requirements of Section 15170, Electric Motors; Section 15171, Medium Voltage Electric Motors, and Section 16000, Basic Electrical Requirements.

3.02 STORAGE OF EQUIPMENT AND MATERIALS

A. Contractor shall store his equipment and materials at the job site in strict accordance with the manufacturer's recommendations and as directed by the Owner or Engineer, and in conformity to applicable statutes, ordinances, regulations, and rulings of the public authority having jurisdiction. Equipment and materials shall not be delivered to the site prior to 90 days in advance of the scheduled installation. Partial payment requests will not be processed for materials delivered prior to 90 days before installation or for materials that are not properly stored.

B. Material or equipment stored on the job site is stored at the Contractor's risk. Any damage sustained of whatever nature shall be repaired to the Engineer's satisfaction at no expense to the Owner. Stored electrical equipment is to be protected from the elements and shall have space heaters energized.

C. Contractor shall not store unnecessary materials or equipment on the job site and shall take care to prevent any structure from being loaded with a weight which will endanger its security or the safety of persons.

D. Contractor shall observe all regulatory signs for loadings on structures, fire safety, and smoking areas.

E. Contractor shall not store materials or encroach upon private property without the written consent of the owners of such private property.

3.03 MANUFACTURER'S FIELD SERVICES

A. The Contractor shall arrange for a qualified Technical Representative from each manufacturer or supplier of equipment who is regularly involved in the inspection, installation, start-up, troubleshooting, testing, maintenance, and operation of the specified equipment. Qualification of the Technical Representative shall be appropriate to the type of equipment furnished and subject to the approval of the Engineer and the Owner. Where equipment furnished has significant process complexity, furnish the services of engineering personnel knowledgeable in the process involved and the function of the equipment. When necessary, the Contractor shall schedule multiple Technical Representatives to be present at the same time for the purpose of coordinating the operation of multiple pieces of related equipment.

B. For each site visit, the Technical Representative shall submit jointly to the Owner, the Engineer, and the Contractor a complete signed report of the results of his inspection, operation, adjustments, and testing. The report shall include detailed descriptions of the points inspected, tests and adjustments made, quantitative results obtained if such are specified.

C. The manufacturer's Technical Representative shall provide the following services.

1. Installation: The Technical Representative shall inspect the installed equipment to verify that installation is in accordance with the manufacturer's requirements. Where required by individual equipment specifications, the Technical Representative shall also supervise the installation of the equipment.

2. Testing: After installation of the equipment has been completed and the equipment is presumably ready for operation, but before it is operated by others, the Technical Representative shall inspect, operate, test, and adjust the equipment as required to prove that the equipment is in proper condition for satisfactory operation under the conditions specified. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for startup and that nothing in the installation will render the manufacturer's warranty null and void. The report shall include date of final acceptance field test, as well as a listing of all persons present during tests.

3. Startup: The Technical Representative shall start up the equipment for actual service with the help of the Contractor. In the event that equipment or installation problems are experienced, the Contractor and the representative shall provide the necessary services until the equipment is operating satisfactorily and performing according to the specifications at no additional cost to the Owner. Unless otherwise noted in the signed site visit report, the report shall constitute a certification that the equipment conforms to the requirements of the Contract and is ready for permanent operation and that nothing in the installation will render the manufacturer's warranty null and void.

4. Training: The Technical Representative shall instruct the Owner's operating personnel in correct operation and maintenance procedures. The instruction shall demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment. Such instruction shall be scheduled at a time arranged with the Owner at least 2 weeks in advance of the training and shall be provided while the respective Technical Representative's equipment is fully operational. The Contractor shall have submitted, and had accepted, the O&M Manuals prior to commencement of training. Training shall be provided to two separate shifts of the Owner's personnel between the hours of 8:00 A.M. and 6:00 P.M. as necessary.

5. Services after Startup: Where required by the individual equipment specifications, the Technical Representative shall return to the project site thirty (30) days after the start up date to review the equipment performance, correct any equipment problems, and conduct operation and maintenance classes as required by the Owner. This follow-up trip is required in addition to the specified services of Technical Representative prior to and during equipment startup. At this time, if there are no equipment problems, each manufacturer shall certify to the Owner in writing that his equipment is fully operational and capable of meeting operating requirements. If the equipment is operating incorrectly, the Technical Representative will make no certification to the Owner until the problems are corrected and the equipment demonstrates a successful thirty (30) days operating period.

D. Services of the Technical Representative will require a minimum of two (2) site visits, one for installation and testing and one for startup and training, and will be for the minimum number of days recommended by the manufacturer and approved by the Engineer but will not be less than the number of days specified in individual equipment sections.

E. The Contract amount shall include the cost of furnishing the Technical Representative for the minimum number of days specified, and any additional time required to achieve successful installation and operation. The times specified for services by the Technical Representative in the equipment Specifications are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

F. The Contractor shall notify the Engineer at least 14 days in advance of each equipment test or Owner training session.

G. The Technical Representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.

3.04 INSTALLATION

A. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation. Equipment shall be installed strictly in accordance with recommendations of the manufacturer. A copy of all installation instructions shall be furnished the Engineer's field representative one week prior to installation.

B. The Contractor shall have on hand sufficient personnel, proper construction equipment, and machinery of ample capacity to facilitate the work and to handle all emergencies normally encountered in work of this character. To minimize field erection problems, mechanical units shall be factory-assembled insofar as practical.

C. Equipment shall be erected in a neat and workmanlike manner on the foundations at the locations and elevations shown on the Drawings.

D. All equipment sections and loose items shall be match-marked prior to shipping.

E. For equipment such as pumping units, which require field alignment and connections, the Contractor shall provide the services of the manufacturer's qualified mechanic, millwright, or machinist, to align the pump and motor prior to making piping connections or anchoring the pump base. Alignment shall be as specified herein.

F. The Contractor shall furnish oil and grease for initial operation and testing. The manufacturer and grades of oil and grease shall be in accordance with the recommendations of the equipment manufacturer.

3.05 ALIGNMENT

A. Set equipment to dimensions shown on drawings. Dimensions shall be accurate to +/- 1/16 inch unless otherwise noted on the drawings. Wedges shall not be used for leveling, aligning, or supporting equipment.

B. General Equipment Leveling: Non-rotating equipment shall be set level to +/- 1/16 inch per 10 foot length (.005 inch per foot) unless otherwise noted on the drawings. Shims shall be used unless equipment is furnished with leveling feet. Set shims flush with equipment baseplate edges. When grouting is required, equipment shall be shimmed to allow a minimum of one inch grout thickness. Grout shall cover shims at least 3 inches. Final level check shall be held for inspection and approval by Engineer before proceeding.

C. Grouting

1. Fill anchor bolt holes or sleeves with grout, after bolt alignment is proven, and prior to placing grout under equipment bases.

2. Surface Preparation. Roughen surface by chipping, removing laitance, and unsound concrete. Clean area of all foreign material such as oil, grease, and scale. Saturate area with water at least 4 hours prior to grouting, removing excess water ponds.

3. Application. Place grout after the equipment base has been set and its alignment and level have been approved. Form around the base, mix grout, and place in accordance with the grout manufacturers published instructions. Eliminate all air or water pockets beneath the base using a drag chain or rope.

4. Finishing. Point the edges of the grout to form a smooth 45 degree slope.

5. After grout has cured (not before 3 days after placement) paint exposed surfaces of grout with shellac.

6. Level Verification. After grout has cured, and immediately prior to drive alignment, recheck equipment for level and plumb. Re-level and square as necessary. Hold final checks for inspection and approval by Engineer.

D. Inspect for and remove all machining burrs or thread pulls in female holes on mating surfaces of mounting frame and machine feet.

E. Inspect and clean equipment mounting base pads, feet, and frames to remove all grease, rust, paint and dirt.

F. Assembled equipment shafts shall be set level to .0015 inches per foot of shaft length (+/- .0005 inches) up to a maximum of 0.015 inches for any length shaft unless the manufacturers requirements are more stringent or unless otherwise noted in the equipment specifications. Use the machined surfaces on which the equipment sets for the base/mounting frame leveling plane. Use the machined shaft surface for equipment leveling plane.

G. Sprocket and Sheave Alignment. Check shaft mounted components for face runout and eccentricity (outside diameter) runout by magnetically mounting a dial indicator on a stationary base and indicating over 360 degrees on a continuous machined surface at the outside diameter of the component. Maximum allowable total indicated face runout and eccentricity for sprockets and sheaves will be per ANSI Standard B29.1-1975.

H. Belt tensioning. Set drive belt tension to manufacturer's specification for the belt type. Recheck alignment after drive tensioning.

I. Thermal/Mechanical Growth. Thermal/mechanical growth corrections for driver and driven machines will be used in vertical and horizontal alignment where applicable. The equipment manufacturer will determine thermal/mechanical growth applicability for any machine and provide the correction offsets to be used.

J. Rotating Shaft Alignment

1. Fixtures will be set up on the driver and driven machine, machines shaft surfaces. Machined coupling hubs may be used only if there is no clearance to mount fixtures directly on the shafts.

2. Primary alignment method for direct drive machines is when coupled. Uncoupled alignment will be used only when approved by the Engineer.

3. Account for possible coupling flex by always rotating coupled machines in the same direction during alignment.

4. Uncoupled machines must be connected so that both shafts turn together without relative motion during alignment.

5. Indicator bar sag will be measured and included for each reverse indicator alignment setup.

6. Reverse Dial Indicator. The final maximum allowable misalignment: vertical and horizontal from the desired targets of .000 inches (for a non-thermal growth machine) or from the given target readings (for a thermal growth machine) must meet BOTH of the following conditions simultaneously: 1/2 the final total indicator reading at each indicator will be no more than shown in the table below AND the final remaining correction at each machine foot be no more than .001 inches of required movement.

Machine Speed (RPM)	Total Misalignment* (inches)
Up to 1800	.002
1800 and greater	.001

* 1/2 indicator reading

3.06 FIELD TESTING

A. Field testing shall be completed in accordance with Specification 01400 – Quality Control. All equipment shall be set, aligned and assembled in conformance with the manufacturer's drawings and instructions. Provide all necessary calibrated instruments to execute performance tests. Submit report certified by the equipment manufacturer’s representative.

3.07 FAILURE OF EQUIPMENT TO PERFORM

A. Any defects in the equipment, or failure to meet the guarantees or performance requirements of the Specifications shall be promptly corrected by the Contractor by replacements or otherwise.

B. If the Contractor fails to make these corrections, or if the improved equipment shall fail again to meet the guarantees or specified requirements, the Owner, notwithstanding his having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Contractor to remove it from the premises at the Contractor's expense.

C. The Contractor shall then obtain specified equipment to meet the contract requirements or upon mutual agreement with the Owner, adjust the contract price to reflect not supplying the specific equipment item.

D. In case the Owner rejects said equipment, then the Contractor hereby agrees to repay to the Owner all sums of money paid to him for said rejected equipment on progress certificates or otherwise on account of the lump sum prices herein specified.

E. Upon receipt of said sums of money, the Owner will execute and deliver to the Contractor a bill of sale of all his rights, title, and interest in and to said rejected equipment; provided, however, that said equipment shall not be removed from the premises until the Owner obtains from other sources other equipment to take the place of that rejected.

F. Said bill of sale shall not abrogate Owner's right to recover damages for delays, losses, or other conditions arising out of the basic contract.

3.08 PAINTING

A. All surface preparation, shop painting, field repairs, finish painting, and other pertinent detailed painting specifications shall conform to applicable sections of Section 09900, Painting.

B. All shop coatings shall be compatible with proposed field coatings.

C. All inaccessible surfaces of the equipment, which normally require painting, shall be finished painted by the manufacturer. The equipment and motor shall be painted with a high quality epoxy polyamide semi-gloss coating specifically resistant to chemical, solvent, moisture, and acid environmental conditions, unless otherwise specified.

D. Gears, bearing surfaces, and other unpainted surfaces shall be protected prior to shipment by a heavy covering of rust-preventive compound sprayed or hand applied which shall be maintained until the equipment is placed in operation. This coating shall be easily removable by a solvent.

3.09 WELDING

A. The Equipment Manufacturer's shop welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirement of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.

B. The Contractor's welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirements of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.

C. The Contractor shall perform all field welding in conformance with the information shown on the Equipment Manufacturer's drawings regarding location, type, size, and length of all welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society, and special conditions, as shown by notes and details.

- END OF SECTION -

SECTION 11183

MULTISTAGE CENTRIFUGAL BLOWERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation four electric motor-driven multistage centrifugal blower units including electric motors, steel bases, inlet filter, inlet throttling valves with electric motor operators, check valves, discharge butterfly valves, control panels, and all necessary auxiliary equipment as specified herein and shown on the Drawings or as required for a complete installation of the system.

B. Equipment shall be provided in accordance with the requirements of Section 11000 – Equipment General Provisions.

C. The completed installation is to be free from excessive vibration, noise, or oil leaks.

D. All equipment specified in this section shall be designed and furnished by the blower manufacturer, who shall be responsible for the suitability and compatibility of all included equipment.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Division 1 - General Requirements

B Section 09900 - Painting

C. Section 11000 - Equipment General Provisions

D. Division 15 - Mechanical

E. Division 16 - Electrical

F. Division 17 - Instrumentation

1.03 SUBMITTALS

A. The Contractor shall submit complete Shop Drawings, Operation and Maintenance Manual, Instructions, and other information for the blower systems and all equipment specified herein in accordance with Section 01300 - Submittals.

B. Shop Drawings shall include full descriptive information of materials used, method of fabrication, sizes, enclosures, ratings and layout dimensions, etc. to demonstrate full compliance with the Contract Documents.

C. Shop Drawings shall include weights of all system components and total weight of the operating blowers.

D. The performance characteristic curves for the blowers shall be submitted with the shop drawings. Performance curves shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity as well as the design criteria specified in Paragraph 2.02, and the curves shall show horsepower draw over the range of SCFM flow rates. Additional operational data for the blowers shall be submitted including recommended vibration alarm settings and operational limits.

E. A complete description of the protective coating system to be used for all components, prior to shipment and after installation, shall be submitted with the shop drawings.

F. A listing of spare parts furnished shall be submitted with the shop drawings.

G. Blower manufacturer shall submit installation instructions in accordance with Section 01300. Installation instructions shall be complete including unloading, check-out following shipment, storage, handling, assembly, anchorage, and start-up instructions and shall be submitted prior to delivery of the blowers.

H. A minimum of three copies of certified test reports including all details of apparatus, procedure, and results and all required calculations shall be submitted for each shop test conducted. Reports for shop tests shall be approved by the Engineer prior to shipment.

I. A detailed shop test plan shall be submitted with the Shop Drawings. The shop test plan shall fully describe the manufacturer's test facilities and the test procedure to be used.

J. Motor literature, illustrations, specifications and engineering data.

K. Instruments including product data sheets, manufacturer’s catalog information, and performance/operation criteria and requirements.

L. Panel, console, and cabinet layout drawings, component product information, wiring diagrams, field wiring requirements, and operator interface graphic layouts specific to the project.

M. Blower control system block diagram, input/output information, hardware layout drawings, interconnection diagrams, and point-to-point interconnection wiring diagrams for field wiring.

1.04 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall arrange for the manufacturer to furnish the services of a qualified service person with at least three years of experience, who is regularly involved in the inspection, operation, and maintenance of centrifugal blowers and blower systems of the size and type being furnished. The service persons shall:

1. Inspect the installed equipment to verify that installation is in accordance with the blower manufacturer’s requirements

2. Witness and check final adjustments and alignments

3. Witness and check start-up of each blower system

4. Assist the Contractor in performing field testing and prepare a written report as specified below.

5. Troubleshoot and correct any mechanical problems with the system that are noted during initial operation.

6. Submit written certification signed by the service person that the system has been properly installed, tested, and adjusted; that the system operates as specified or as required, including date of field test, as well as a listing of all persons present during the tests.

7. Investigate and supervise correction of any operating problems that may arise during the guarantee period of the equipment.

8. Coordinate communications with plant control system via the PLC network connection.

B. The services of a qualified manufacturer's technical representative shall be furnished at no additional cost to the Owner and shall be provided in accordance with Section 11000, Equipment General Provisions. Field services shall include as a minimum the site visits listed below. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

Service	**Number of Trips**	**Number of Days/Trip**
Installation and Testing	1	2
Startup and Training	1	1
Services after Startup	1	1

C. The manufacturer’s service person shall sign in and out every day on-site and shall comply with all Owner requirements for visiting the site.

1.05 QUALITY ASSURANCE

A. The materials covered by the Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per the manufacturer’s recommendations.

B. All materials shall be new, and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the units are to be subjected and shall conform to all applicable sections of these specifications. All parts of duplicate machines shall be interchangeable without modification. The construction of the blowers shall be such that the blowers will not be damaged during continuous operation and will not have undue vibration above the blower's surge limit. The design and construction of the blowers shall not cause any unbalanced floor loadings.

C. The Contractor shall protect blower system components at the project site and during installation. Contractor shall be required to place blowers onto their pads within 24 hours

after arrival of the blowers at the site. The Contractor shall be responsible for scheduling and coordinating deliveries of blowers with the manufacturer to minimize the time that blowers are on-site and not installed. The Contractor shall be responsible for any additional cost incurred for storage of blowers. The Contractor shall connect space/strip heaters and manually rotate shafts as recommended by the manufacturer.

1.06 WARRANTY

A. All blower system components specified herein, including but not limited to multistage centrifugal blowers, motors, control panels, valves, and accessories, are to be warranted to be free of defects in materials and quality for a period of not less than two years from the date of acceptance. Warranty and Guarantee shall be as specified in Section 11000.

PART 2 -- PRODUCTS

2.01 GENERAL

A. The aeration blowers shall be multistage, vertically-split, centrifugal type. The blowers shall be driven at the inlet end by direct coupled electric motors with flexible couplings and guards as specified herein. The blowers, motors and all ancillary equipment shall be suitable for outdoor installation, uncovered, and in full sun exposure.

B. The blowers shall be Model 1605 with three A2 impellers and two A3 impellers and Model 67106 with six 204 impellers as manufactured by Gardner Denver, Inc.; or Model 451.04 with three C211 impellers and one C202 impeller and Model 500.04 with three A202 impellers and one A101 impeller as manufactured by Continental Blower, LLC. The model, number and type of impellers shall be verified by the blower manufacturer. Any modifications of the requirements presented herein shall be at the expense of the Contractor and shall be submitted to the Engineer for review, comment and acceptance.

C. The Contractor shall make all alterations required to structures, equipment, piping, controls, or other work shown in the Contract Drawings that may be required for the blower systems ultimately furnished. Any kind of modification required for the installation of the blower system shall be at the expense of the Contractor and shall be approved by the Engineer during shop drawing review.

2.02 PERFORMANCE REQUIREMENTS

A. The proposed blowers shall satisfy the conditions of service and requirements listed below. Standard cubic feet per minute (SCFM) is defined as the delivered airflow rate at the blower discharge in terms of standard conditions (68°F, 14.7 psia and 36% relative humidity). The blowers shall be capable of delivering the specified design flow rate per blower (in SCFM) at the specified discharge pressure at the minimum inlet pressure, design maximum air temperature and relative humidity at the design maximum temperature as specified for the blower primary design point below. The design air temperatures and inlet pressure listed shall be at the inlet to the blower and do not include the impacts of inlet throttling. Motor horsepower shall not exceed the maximum rated motor horsepower specified. The blowers shall be capable of turndown to the minimum flow rate specified below throughout the ambient temperature range specified.

	Small Blowers	Large Blowers
Ambient Conditions		
Site Elevation, ft	15	
Ambient Barometric Pressure, psia	14.7	
Ambient Temperature Range, °F	25 - 104	
Ambient Relative Humidity Range, %	0 - 100	
Design Inlet Conditions		
Minimum Inlet Pressure, psia	14.4	
Design Maximum Air Temperature, °F	98	
Relative Humidity at Design Max. Temperature, %	60	
Capacity Requirements		
Number of Blowers	2	2
Mass Flow Rate/Blower at Design Inlet, SCFM	7,400	11,100
Volumetric Flow Rate/Blower at Design Inlet, ICFM	8,221	12,332
Discharge Pressure, psig	7.2	7.2
Discharge Pressure (absolute), psia	21.9	21.9
Maximum Shaft Power at Design Point, HP	330	511
Minimum Flow Rate/Blower, SCFM	4,200	5,000
Minimum Surge Pressure - Unthrottled, psig	8.0	8.0
Motor Requirements		
Voltage, V	460	460
Maximum Horsepower, HP	400	600
Enclosure Type	TEFC	TEFC

B. Surge volume of each blower shall be less than the minimum flow rates indicated in the table above under the range of ambient temperature conditions shown. Surge volume is defined herein as the airflow rate at which the discharge throttled blower exhibits the first indication of pressure pulsations or flow reversal.

C. The large blowers shall not draw more than 600 horsepower at any flow rate for any temperature in the range of 25°F to 104°F and the inlet pressure specified, and the small blowers shall not draw more than 400 horsepower at the same conditions. The blower shall have a "non-overloading" characteristic through the use of backward leaning impellers.

D. The blower system will be designed to deliver varying airflow rates by throttling at the blower suction. Control of minimum airflow delivery and inlet valve throttling will be based on blower drawn amperage or power.

2.03 BLOWER MOTORS

A. The blower manufacturer shall be responsible for furnishing the electric motors for each blower. Maximum rated horsepower for each blower is specified in Paragraph 2.02. The manufacturer shall be responsible for the proper selection, testing, installation, and operation of the motors and for coordinating the motors with the compressor equipment. Motors shall be new and both materials and quality shall be of the very best quality. Motors shall be XE Premium Efficiency motors as manufactured by Baldor/Reliance Electric Company; Nidec Motors; Toshiba Industrial and Power Systems, Inc.; Siemens Energy & Automation, Inc.; or General Electric Company.

B. Motors shall be horizontal squirrel cage induction motors designed in accordance with the latest ANSI, NEMA, and IEEE standards. Motors shall be 480 volts, 3 phase, 60 Hz. Motors shall be designed and manufactured for continuous duty for operation under the following conditions:

   1. Altitude below 100 ft.

   2. Ambient temperature ranging from 20°F to 104°F.

   3. Voltage variations of plus or minus 10 percent.

   4. Frequency variation of plus or minus 5 percent.

   5. Combined voltage and frequency variation of plus or minus 10 percent with frequency variation not exceeding plus or minus 5 percent.

C. The motor shall provide a service factor of 1.15. Motor horsepower shall be equal to or greater than the load over the full range of operating conditions. Motor speed shall not exceed 3600 rpm.

D. Motor torque characteristics shall be at least 20 percent greater than the maximum full load torque requirements over the full range of operating conditions from start-up to full load.

E. Motor shall be in TEFC enclosures and shall be designed for quiet operation. Motor sound pressure shall not exceed nominal 87 dBA, measured 3 feet from the motor.

F. Motors shall provide premium efficiencies and power factors throughout their operating range. The power factors specified shall be achieved without the use of power factor correction capacitors.

G. Motor insulation shall be Class F insulation; however, temperature rise shall be limited to that of Class B insulation. Manufacturer's premium grade insulation shall be used.

H. The stator shall be assembled from high grade electrical sheet steel laminations adequately secured together. Stator windings and end turn connections shall be fully braced to withstand all mechanical, electrical, and thermal stresses. The shaft shall be made of high-grade machine steel or steel forging and of size and design adequate to withstand the load stresses. The rotor shall be fabricated of high-grade electrical sheet steel laminations adequately fastened together and to the shaft.

I. Bearings shall be grease lubricated ball bearings. Bearings shall be capable of being inspected or replaced without disturbing alignment.

J. Motor leads shall be suitably marked and identified. Each motor shall be provided with an oversized terminal box with space for full stress cone terminations and shall be constructed of cast iron or fabricated steel, neoprene gasketed and bolted. The three stator phase leads shall be provided with 2-hole pad connectors for the incoming cables.

K. Motors shall be designed and manufactured for operation in the direction required for the blowers. The phase sequence shall be marked permanently and plainly inside the stator lead junction box.

L. Motors shall have breather and drain plugs to allow for drainage of any moisture from inside.

M. Motor Winding Temperature Monitors: Each motor shall be provided with six (two per phase) platinum resistance temperature detectors (RTDs) embedded in the stator winding. RTDs shall be 100 ohm, platinum, 3 wire type having a stability of better than 0.2 percent of maximum exposed temperature for one year of service, or 0.25°C, whichever is greater. Two detectors per phase are required and shall be placed at locations determined by the manufacturer to give close approximation of the hottest spot temperatures.

N. Motor Bearing Temperature Monitoring: Each motor shall be furnished with two platinum motor bearing resistance temperature detectors (RTDs) for connection to the respective blower local control panel PLC input/output interface. Motor bearing RTDs shall be mounted in Type 316 stainless steel thermowells coordinated and furnished by the blower Supplier. Locations shall be coordinated with the blower manufacturer.

O. Motor Bearing Vibration Monitoring: Each blower shall be furnished with two motor bearing vibration sensors for connection to the respective blower local control panel PLC input/output interface. Locations shall be coordinated with the blower manufacturer.

P. The CONTRACTOR shall furnish, install and test all requisite conduit and wiring and terminations between all supplied instruments and each local blower control panel, as necessary.

Q. Motors shall be supplied with space heaters for 120V operation. Starters shall include circuitry and 120-volt power supply to automatically power the space heaters when the motors are not running and vice-versa.

R. Motor power supply shall be connected to an oversized junction box mounted on the motor housing.

S. Motors shall comply with Division 16 requirements, except where modified herein.

2.04 BASES

A. A welded steel fabricated base shall be provided for mounting the blower, electric drive and driver base. The base shall be of a rigid box section shape. The box section shall be properly ribbed for stiffness and present large bearing areas for carrying the load on the foundation and shall include lifting lugs. The base shall be rigid to prevent deflection during start-up and normal operation that would affect alignment. Rubber vibration isolation pads shall be provided between the concrete mounting and the base of the blower unit. The base shall have machined surfaces at blower and motor installation pads.

2.05 HOUSING AND HEADS

A. The housing, inlet and outlet heads shall be constructed of close-grained cast iron sections, ASTM A48, fitted with babbit joints held securely by steel tierods and able to withstand the operating pressures. Heads shall be provided with mounting legs. Approved eye bolts or lugs shall be provided for lifting. Where the blower shaft passes through both the inlet and outlet heads, non-contact labyrinth seals with babbit inserts or carbon ring seals shall be provided to prevent air leakage and to assure non-contamination of the bearing lubricant. Internal seals between stages shall be of the labyrinth type to restrict inter-stage leakage. Inlet and outlet flange connections shall be ANSI Standard 125-pound drilled through bolt pattern and will be an integral part of the heads.

B. Air passage shall be finished by hand or other means to obtain smooth surfaces and minimize friction losses. Casing shall be accurately machined to gauge, where necessary, to ensure interchangeability of all parts.

C. The compressors shall be built from parts cast in patterns from which previous units have been built and tested. The compressor shall be of the manufacturer's standard design.

2.06 IMPELLERS AND SHAFTS

A. Impellers shall be cast aluminum alloy, keyed to the shaft and held by a lock nut. Hubs of the impellers shall butt against each other directly or through one-piece metal spacers. Impellers shall be individually precisely machine balanced. Impellers shall be individually replaceable without requiring dynamic rebalancing of the entire rotating assembly to maintain factory vibration specifications. Vibration shall not exceed 1.25 mils in the vertical plane measured at the blower bearing housing.

B. Shaft shall be of sufficient diameter to operate below the first critical speed and be made of high grade hot-rolled steel. Shaft speed shall not exceed 3,600 rpm.

2.07 BEARINGS

A. Each blower shall have two oil lubricated ball bearings which can be lubricated, inspected or replaced without disconnecting piping or disassembling the blower. The bearings shall be contained in outboard bearing housings designed to isolate the bearings from blower temperature.

B. A balance piston will be integrally shaft mounted on the discharge end of the blower. The balance piston will reduce the thrust load on the thrust bearing by 75 percent.

C. Lubrication shall be accomplished by means of an oil slinger that circulates lubrication oil from an inner reservoir through the bearing and returns the oil to the outer reservoir. Oil recirculation shall be at the rate of at least 1.5 pints per minute. The oil level in the bearings housings shall be viewable through a sight glass.

D. Blower Bearing Temperature Monitoring: Each blower shall be furnished with two platinum motor bearing resistance temperature detectors (RTDs) for connection to the respective blower local control panel PLC input/output interface. Blower bearing RTDs shall be mounted in Type 316 stainless steel thermowells coordinated and furnished by the blower manufacturer

E. Blower Bearing Vibration Monitoring: Each blower shall be furnished with two motor bearing vibration sensors for connection to the respective blower local control panel PLC input/output interface. Locations shall be coordinated by the blower manufacturer.

F. The CONTRACTOR shall furnish, install and test all requisite conduit and wiring and terminations between all supplied instruments and each blower local control panel as necessary.

2.08 COUPLINGS

A. A flexible, disc spacer coupling of an approved type shall be furnished for connecting the blower and motor. The coupling design shall take care of inaccuracies of alignment and permit axial adjustment. The coupling shall have a minimum service factor of 1.35 over motor nameplate horsepower. Spacer coupling shall have a minimum length of seven inches. The construction of the couplings shall be such that either hub of a unit may be removed without disturbing adjustment of the blower or motor. A factory laser alignment shall be conducted prior to shipment to facilitate alignment in the field.

B. The manufacturer shall provide a suitable steel or “OrangePeel” aluminum coupling guard for the coupling between blower and motor. The guard shall have a sheet metal top covering and expanded metal front and be designed to meet current OSHA requirements.

C. The manufacturer shall provide a torsional critical speed analysis to ensure that the blower, motor, and coupling are properly designed and to insure that there are no torsional critical speeds within the operating range of the unit.

2.09 PRESSURE, TEMPERATURE AND POWER MONITORING

A. Temperature Indicating Transmitters: Each blower shall be provided with inlet and discharge thermowells and temperature indicating transmitter assemblies on the suction and discharge sides as shown on the Contract Drawings and located as recommended by the blower manufacturer.

B. Temperature indicating transmitters shall be mounted in Type 316 stainless steel thermowells coordinated and furnished by the blower Supplier. Thermowell locations on piping shall be coordinated by the blower manufacturer.

C. Differential Pressure Transmitter: Shall be provided at the discharge of the filter/silencer unit, as shown on the Contract Drawings. Vacuum and pressure taps shall be provided by the Contractor at locations selected for stable measurement and accurate evaluation of pressure loss across the filter.

D. Instrumentation shall comply with the requirements of Division 17.

E. Instrumentation shall withstand temperatures up to 250ºF

F. The Contractor shall furnish and install all requisite conduit, wiring, testing and terminations from new field instruments to the blower local control panels as necessary.

G. The blower manufacturer shall provide current monitoring devices (CTs) to be installed in the RVSS starters by the electrical subcontractor and/or RVSS manufacturer. The blower control panel PLC shall receive motor current signals from the CTs for hardwired blower surge protection as shown on the drawings. Coordinate requirements with Division 16 Electrical.

2.10 BLOWER CONTROL PANELS (FCP-B-1100, FCP-B-1200, FCP-B-1300, FCP-B-1400)

A. The blower supplier shall furnish a NEMA 12 blower control panel for each of the four blowers. Each blower control panel shall include a PLC for monitoring, displaying, and protecting the blowers, including a PLC operator interface panel with touchscreen. Blower control panel shall be suitable for wall-mounted installation by the Contractor within the pre-manufactured blower electrical building. Each blower control panel shall contain controls for blower motor starting and stopping, surge and overload detection, alarm and emergency shutdown systems, and for the inlet throttling valve. The panel shall be supplied with a disconnect switch on the 120-volt power supply to the panel.

B. Each blower control panel shall be furnished with a PLC. PLC shall be Allen Bradley CompactLogix (see Section 17120). The PLC shall be provided complete with rack, power supply, I/O cards, special function cards, instructions, memory, input/output capacity, operator interface unit (see Section 17125) and appurtenances to provide all required features and functions.

1. Additional communication ports shall be provided for the Operator Interface and other devices as required.

2. Each blower control panel shall include a UPS to provide uninterruptible power to the PLCs for a minimum of 30 minutes in the event of an electrical power failure.

3. Each blower PLC system shall be provided with an Ethernet network interface card for communications with PLC-10 (new plant PLC within new Blower Electrical Building).

C. Each blower control panel shall be furnished with a minimum 6-inch color touchscreen operator interface mounted on the front of the NEMA 12 enclosure. The operator interface shall be Allen Bradley PanelView Plus 7 series or equal. The operator interface shall provide the following functions at a minimum:

1. Surge protection with impending warning and trip functions in amperage and horsepower (calculated) displayed as digital readouts.

2. Blower bearings vibration level indication with impending warning and trip functions and levels displayed as digital readouts. A warning shall be activated through the monitor when vibration exceeds 0.2 inches/sec. An alarm and shutdown shall be provided when vibration exceeds 0.4 inches/sec. Blower system manufacturer to confirm final settings.

3. Blower bearings temperature indication with impending warning and trip functions and levels displayed as digital readouts.

4. Blower “Run” Light (Red)

5. Common Warning Light (Amber)

6. Common Fault Alarm Light (Amber)

7. Motor windings temperature indications with impending warning and trip functions and levels displayed as digital readouts.

8. Inlet butterfly valve position indication with automatic/manual control functions, status monitoring (% open, fault status, available status (power on and in remote)) with % open and set-point displayed as digital readouts.

9. Inlet and discharge air temperature indications with impending warning and trip functions and levels displayed as digital readouts.

10. Inlet filter differential pressure indications with impending warning and trip functions and level displayed as digital readouts.

11. Motor horsepower and amperage displayed as digital readouts (signal from the current transformers).

12. Blower flow rate calculated from motor amperage expressed as SCFM displayed as a digital readout. Inlet air temperature measurement shall be used to compensate for changes in the amperage/SCFM relationship with temperature.

D. Adjustable time delays shall be incorporated to allow uninterrupted motor starts and stops to prevent nuisance shutdowns.

E. All trip functions shall be frozen upon a shutdown so that shutdown status can be determined and the values at shutdown preserved. The PLC shall store and display the 50 most recent shutdown alarms including identification of alarms, time and date of occurrence, and value on trip.

F. The control panel shall be completely pre-wired and tested at the factory by the blower system manufacturer.

G. An as-built diagram of the completed panel shall be encased in plastic inside the panel.

H. Engraved plastic nameplates shall be securely mounted on the front and inside of each blower panel to designate the blower served and to identify the various devices, instruments, etc. Nameplates shall have white letters on a black background.

I. Panel layout and wiring diagrams shall be submitted with the submittal drawings.

J. Alarms shall not be annunciated under normal start-up and shut-down conditions.

K. Motor and blower bearing vibration and temperature warning and alarm/shutdown settings and blower inlet/discharge air temperature warning and alarm/shutdown settings shall be as recommended by the blower supplier (except for inlet air temperature, which will be for indication only).

L. The surge protection system shall prevent surge conditions by use of both motor horsepower and amperage. Adjustable time delays shall be incorporated to prevent nuisance shutdowns. Initial setting for the large blowers shall be 600 horsepower (or equivalent current) for overload shutdown and 350 horsepower (or equivalent current) for low horsepower (surge) shutdown. Initial setting for the small blowers shall be 400 horsepower (or equivalent current) for overload shutdown and 240 horsepower (or equivalent current) for low horsepower (surge) shutdown. The Contractor shall coordinate the range and calibration information between the blower manufacturer and electrical subcontractor.

M. The PLC shall provide a common failure relay output activated by any of the shutdown conditions. Another relay output shall be wired into the motor control circuit in the blower motor starter to shut down the blower.

N. Panel shall be prewired with a master terminal strip to accommodate all inputs and outputs. A UL label is required. Each end of each wire shall be identified by a unique wire number printed on a heat shrunk sleeve marker.

O. All wiring external to control components within the panel shall be multi-strand copper no smaller than 14 gauge with each end properly numbered according to the manufacturer's drawings. Wiring will be done in a professional quality manner and run in covered trays. All wires that attach to door mounted components shall be neatly bundled and tied. All external connections shall terminate on a common terminal strip with at least 20% spare connection points.

2.11 REQUIREMENTS FOR INTERFACE WITH THE PLANT PLC SYSTEM

A. The Blower Manufacturer shall provide source code for all blower control and monitoring programs in printed form and on uploadable media to enable the Owner to reload all necessary programming onto a new blower PLC in the event of PLC failure.

B. The Contractor shall provide all coordination required for communication of information between the blower control panels and the Plant PLC System. The blower manufacturer will make available in separate registers the required digital and analog information to the Plant PLC System through network communication. The blower manufacturer shall submit copies of the graphic displays for approval. The Contractor shall coordinate with the control system Subcontractor under Division 17 to develop the graphic displays in the existing Plant PLC System display format protocol. The Plant PLC System (by the control system Subcontractor under Division 17) is to receive all necessary information from each blower control panel PLC to be able to do the following:

1. Log all monitored points for trend analysis

2. View real time trends

3. View historical information

4. Display graphs and charts

5. Date/time history of alarms including surge

2.12 BLOWER START-UP AND SHUTDOWN SEQUENCE CONTROL PROGRAMS

A. The blower start-up and shutdown sequence control programs shall be provided by the blower manufacturer in each blower control panel PLC as follows:

1. A blower may be called to start or stop in either of the following ways:

   a. Manually at the blower control panels through the operator interface panel.
   b. Remotely through the Plant PLC System (remote-manual)

2 When a blower is called to start, a "Blower #__ Start-up Sequence Initiated" message shall be shown on the blower local control panel display and on the Plant PLC System display. All messages to be displayed on all blower PLC operator interfaces shall be provided by the Plant PLC System through the communication network. Status of delay timers showing countdown time shall be displayed during a start-up and shutdown sequence.

3. Automatic control of the dissolved oxygen control valves and inlet throttling valves by the Plant PLC System during a start-up sequence shall be discontinued until completion of the start-up sequence.

4. A "Blower #___ Start-up Sequence in Progress" message shall be shown on the blower local control panel display and on the Plant PLC System display and shall remain on the screen in flashing mode until the start-up sequence is completed.

5. The Plant PLC System or the operator through the operator interface at the blower control panel shall provide a command to the blower control panel to start its respective blower. The blower control panel PLC shall confirm that no alarm conditions exist and the blower is available for starting. In the case of a blower failure or if a blower is locked out by a PLC-based "permissive", the Plant PLC System shall prompt the operator to start the next available blower according to the control program in the Plant PLC System. Indication of the next blower to be started and the next blower to be shut down through the strategy shall be provided on the Plant PLC System graphic displays.

6. The blower control panel PLC shall move the inlet throttling valve on the blower to be started to the "Start-up" position. The Plant PLC System will provide a command to the PLCs of blowers already operating to move inlet butterfly valves to their start-up position. The blower control panel PLC will use continuous 4-20 mA position set-point and position feedback information from the operators for the inlet throttling valves to monitor position for start-up. Indication that the PLC is "Positioning the Inlet Throttling Valves" shall be provided on the blower local control panel display and on the Plant PLC System display. Failure of any of the valves to move to their required positions within the time required shall initiate a "Start-up Sequence/Valve Failure" alarm through the blower control panel PLC, shall terminate the start-up sequence, and shall provide alarm indication on the blower local control panel display and on the Plant PLC System display.

7. The blower control panel PLC shall provide a start (dry contact) signal to the Blower Motor Starter to energize the drive motor. The blower control panel PLC shall receive a feedback signal from the starter confirming that the main drive motor starter has been energized via the motor starter auxiliary contact. If the start verification is not received in 20 seconds, the start sequence is terminated on a “No Motor Feedback Alarm (Sequence Failure).” After the motor feedback signal is received, the inlet throttling valves shall be positioned by the Plant PLC System according (see Division 17). A “Blower #____ Start-up Sequence Completed” message shall be displayed on the blower local control panel display and on the Plant PLC System display.

8. When a blower is called to stop either through the Plant PLC System or the local operator interface, a "Blower #___ Shutdown Sequence Initiated" message shall be shown on the blower local control panel display and on the Plant PLC System display.

9. After the command is received from the Plant PLC System to shut down the blower (or a blower shutdown is initiated manually through the touch screen), the blower control panel PLC shall stop the blower and shall move the inlet throttling valve to

the start-up position. A "Blower # ____ Stopped" message shall be shown on the blower local control panel display and on the Plant PLC System display.

10. Emergency Stop capability shall be provided at the blower, through the local blower control panel, at the motor starter and through the Plant PLC System through a single-click function. Emergency Stop shall de-energize all equipment on the blower base. The blower will not be permitted to be reset or reactivated until the maintained Emergency Stop has been manually released.

11. The blower control panel shall include protective shutdown interlocks to protect the blower from abnormal operating conditions including:

    a. Motor High Bearing/Winding Temperature
    b. High Discharge Air Temperature
    c. High Motor Horsepower
    d. Surge
    e. No Run Status Contact Feedback from Starter During Starting
    f. Loss of Run Status Contact Feedback from Starter
    g. Sequence Failure
    h. Motor/Blower High Vibration
    i. Pushing Emergency Stop Pushbutton
    j. PLC Failure
    k. Blower Bearing High Temperature
    l. Inlet Throttling Valve Fault or “Not Available”

2.13 BLOWER MACHINE MONITORING PROGRAMS

A. The Blower monitoring programs shall be provided by the blower manufacturer in each blower control panel as follows:

1. Monitoring and protection of the blowers from abnormal operating conditions shall be provided through the PLC.

2. Horsepower and current inputs to each PLC shall be from a current transformer provided in the motor starter.

3. Provide monitoring of all analog inputs. The PLC shall shut down the blower if inputs are not within the acceptable range. Hold-out circuitry shall be provided in the PLC programming to prevent shut-down on alarm condition while the blower is being started.

B. The following is a general listing of the minimum data link, analog, CT and RTD inputs to the PLC at each blower control panel. Data link, analog, CT and RTD inputs shall be monitored/displayed at the local blower control panel and monitored/logged/displayed through the Plant Distributed PLC System via network communication.

1. Blower RTD Drive-End Bearing Temperature
2. Blower RTD Non-Drive-End Bearing Temperature
3. Blower Inlet Air Temperature
4. Blower Discharge Air Temperature
5. Blower Drive-End Bearing Vibration
6. Blower Non-Drive-End Bearing Vibration
7. Blower Horsepower (from CTs)
8. Blower Amperage (from CTs)
9. Inlet Throttling Valve Position
10. Motor RTD Winding Temperatures
11. Motor RTD Drive-End Bearing Temperature
12. Motor RTD Non-Drive-End Bearing Temperature
13. Motor Drive-End Bearing Vibration
14. Motor Non-Drive-End Bearing Vibration
15. Inlet Filter Differential Pressure

C. The blower control panel PLC shall include programming to report the order in which alarm conditions are received, such that operators can determine the alarm that caused blower shut-down.

D. Discrete inputs to each blower PLC shall include:

1. Blower motor run status (from starters)
2. Electrical malfunction alarm (from starters)
3. Inlet throttling valve operator in local
4. Inlet throttling valve operator “available” (power on and in remote)
5. Inlet throttling valve operator fault
6. Surge Indication Alarm

E. Discrete outputs from the blower control panel PLC shall include:

1. Blower Start (to starter)

2. Blower Stop (to starter)

3. Impending surge indication (not a discrete output but displayed on OIT)

F. Analog outputs from the blower PLC shall include:

1. Inlet Throttling Valve Position Set-point (to valve)

G. Discrete and analog inputs to the blower control panel PLCs from the Plant Distributed PLC System shall be as shown on the Drawings and generally include, but are not limited to, the following:

1. Blower start command

2. Blower stop command

3. Inlet Throttling Valve Position Set-point

2.14 EQUIPMENT IDENTIFICATION

A. Each blower shall be provided with a substantial stainless steel nameplate, securely fastened in a conspicuous place and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data (flow in scfm, discharge pressure, speed and design inlet conditions).

2.15 PRESSURE GAUGES

A. Inlet and discharge pressure gauges shall be provided on the suction and discharge of each blower. Vacuum and pressure tap locations shall be selected for stable measurement and accurate evaluation of pressure rise across the blower.

B. The inlet vacuum gauge shall be located upstream of the inlet throttling valve and shall be a bellows gauge with a range of 0-10 inches water vacuum. Scale shall be a 270° arc. Dial size shall be 4-1/2 inches with black phenolic case. Gauge tap shall be 1/4 inch minimum.

C. The discharge pressure gauge shall be a 316 stainless steel bourdon type with a range of 0-12 psi. Scale shall be a 270° arc scale with figure interval every 1 psi and minor graduations every 0.1 psi. Dial size shall be 4 1/2 inches with black phenolic case. Gauge tap shall be 1/4 inch minimum.

D. Gauges shall have an accuracy of ±1 percent. All gauges shall be by the same manufacturer and meet the requirements of Section 17650 – Pressure Gauges except where specified herein.

2.16 EXPANSION AND FLEXIBLE COUPLINGS

A. Inlet and discharge filled, single arch expansion joints shall be provided for each blower as shown on the Drawings. Each expansion joint shall be capable of withstanding the vacuum and pressure under all operating conditions and shall be rated for 250°F continuous service. Expansion joints shall provide a minimum of 2-1/4 inches of movement in compression, 1-1/2 inches of elongation, and 1-1/4 inches of lateral movement. Expansion joints shall be Maxi-Joint Style 1101 as manufactured by General Rubber Corporation or equal.

2.17 CHECK VALVES

A. The blower manufacturer shall furnish discharge check valves for each blower as shown on the drawings. Check valves shall be a wafer type discharge check valve of the dual, flat-plate type with center hinge, metallic center post, spring or non-spring closure, steel or cast iron body, Viton-B seal, aluminum-bronze plates, Inkonel 600 springs, and rated for temperatures up to 300°F. Check valve shall be Crane Duo Check II, Flexi-Hinge Type 518, or equal. The check valves shall be installed by the Contractor as shown on the Drawings. The Contractor shall perform any piping modifications necessary to incorporate the check valve provided by the blower manufacturer at no cost to the Owner. Check valves shall be installed in the horizontal position.

2.18 INLET THROTTLING AND DISCHARGE ISOLATION VALVES

A. The blower manufacturer shall furnish inlet throttling butterfly valves with electric operator and discharge isolation butterfly valve with manual handwheel operator for each blower as shown on the drawings. The blower manufacturer shall verify the diameter of the blower inlet throttling valves to guarantee adequate blower control to meet the minimum and maximum flow requirements under the conditions provided in Paragraph 2.02.

B. The butterfly valves shall be installed by the Contractor as shown on the Drawings. The Contractor shall perform any piping modifications necessary to incorporate the butterfly valves provided by the blower manufacturer at no cost to the Owner.

C. Isolation valves and throttling valves shall be resilient-seated butterfly valves as manufactured by Centerline (Crane), Bray, or Dezurik. All valve components shall be suitable for continuous operation at temperatures up to 250°F with a 25 psig minimum working pressure. Materials of construction shall be as specified below.

1. Valve bodies – Ductile Iron

2. Valve discs and shafts – 316 stainless steel

3. Valve seals – EPDM, PTFE or Viton (as required to meet the above temperature requirements)

D. Valves less than 30 inches shall be flanged or have a wafer or lug style body and be compatible with ASME B16.1 flanges. The Contractor shall coordinate flange connections upstream and downstream of wafer valves. Valves 30 inches or larger shall have flanged end connections conforming to ASME B16.1, 125-pound rating.

E. Motor actuators for inlet throttling valve shall be 120-volt actuators manufactured by Harold Beck and Sons, Inc. Operator shall be furnished with 120-volt, single phase, 60 Hz AC, TENV, permanent magnet synchronous motor specifically designed for modulating service.

1. Motor shall be non-coasting, suitable for high duty cycle conditions, and shall be self-locking and self-releasing without the use of a separate brake winding, mechanical brake, or worm gear mechanism. The motor shall be capable of up to 60 starts/stops per minute or a temporary stall condition without overheating. Triacs shall be utilized for solid-state switching. Torque capacity of the operators shall be sufficient to operate the valves with a maximum differential pressure of 15 psi. Motor shall not overheat or fail when in continuous stall condition for 72 hours. No electrical or thermal overload protection shall be required for protection of a stalled or cycling operator.

2. Control drive shall be designed to stay in place upon loss of power and shall be capable of holding a load equal to at least 200% of the model's rated output. Stall torque shall be self-limiting, not exceeding 2.5 times the rated torque. Torque switches shall not be required. Control drive shall be able to operate in any mounting orientation.

3. Gear train shall have high efficiency spur gears constructed of heat-treated alloy steel or ductile iron only. Gears shall be rated at twice the output torque of the operator, so that a continuous stall condition of 72 hours will not create any significant wear or performance degradation. The drive shall automatically discontinue motor operation when the motor current is detected to be flowing in the same direction for 300 seconds. Over-travel of operator shall be prevented by internal mechanical stops cast into the operator. Operating time between full limits of travel shall be no less than 60 seconds.

4. A low-speed, disc-type, solid cast handwheel shall be provided, directly connected to the motor's rotor, for manual operation. A mechanical indicator of valve position shall be provided and attached to the main output shaft driving the load. No declutching mechanism shall be required for manual operation.

5. Linkage between operator and valve shall be by crank arms and connecting rod, with adjustable starting point of valve position and adjustable rod length. Operators shall stop precisely within 0.15 degrees of the desired control position. Operator output shaft shall be stainless steel. Stem shall be self-locking when the motor is deenergized. Modular construction and special lubrication shall permit the operator to be mounted in any position.

6. The operator shall be provided with four individual compartments for the motor, gearing, wiring terminals, and auxiliary switches plus position sensing device. Compartments shall be provided with moisture and dust proof rigid cast covers. All switches, wiring, relays, etc., shall be brought to a gasketed and sealed terminal board for field connection. Two conduit entries shall be provided with the actuator, one 1-inch NPT for signal wiring and one 1-inch NPT for power wiring.

7. Two SPDT limit switches for over-travel protection and four auxiliary SPDT limit switches (two normally open, two normally closed) shall be provided on all operators. Limit switches shall be snap acting, SPDT, silver alloy contacts rated for 6 amperes at 120 VAC. Switches shall have lubrication free nylon rollers, polished stainless steel roller axle, and tempered blades. Switches shall be infinitely adjustable over the full range of valve travel. Limit switches shall be wired to a terminal board for remote output. Drive shall also have integral mechanical stops, capable of limiting travel of the drive and load, with or without the drive motor.

8. The operator shall be provided with 4-20 mA output signals for valve position feedback. Continuous position sensing of valve position shall be provided. Position sensing shall require no contacting or wiping surface. The position sensing unit shall be provided integral with the operator and shall provide a linear 4-20 mA output signal, approximately proportional to valve percent open.

9. Modulating valve actuators shall be designed to respond to a 4-20mA DC analog signal as specified herein or as required to coordinate with the requirements of Division 17.
    a. Modulating valve actuators designed to respond to a 4-20 mA DC signal shall be provided with a valve positioner which shall position the valve proportional to an externally generated 4-20mADC signal. The valve positioning control circuitry shall position the valve, in steps down to 0.15°, by comparing the command signal with the present valve position as indicated by the feedback rotary variable differential transformer (RVDT) mechanism. The control circuitry shall be field adjustable to fail to the “open,” “closed,” or “last” position on loss of 4-20 mA DC command signal.

10. All dry contacts shall be rated for 6A at 120VAC. Four (4) unpowered contacts shall be provided, three of which shall be selected to indicate valve “Opened” position, valve “Closed” position, and “Auto” status of the actuator. “Fail” status of the actuator shall be monitored from a separate terminal. The “Fail” contact shall activate upon a stall condition, actuator over-temperature, open feedback loop, or loss of signal event.

11. Electrical control schematic diagrams shall be provided by the actuator Manufacturer. Interconnecting wiring information shall be submitted including terminal numbers, color coding, and the name and terminal numbers, for items to which the wiring is to be connected.

12. Enclosure shall be totally enclosed, cast, weatherproof, dust-tight, NEMA 4X construction, and IP68 rated. Separate conduit entrances shall be available for power and control wiring connections.

13. Valve actuators shall be provided with corrosion protection package to include stainless steel rods, bearings, output shaft, crank pin, linkages, and hardware

14. Local Controls

a. A five-position, drive-mounted electric handswitch shall be provided to permit local electrical operation of the unit for control adjustment or operation on loss of control signal. All switches, wiring, relays, etc. shall be brought to a terminal board for field connection. The sequence of the handswitch shall be “AUTO”, “STOP”, “CW”, “STOP”, “CCW”.

i. When the handswitch is in the “Auto” position, the actuator shall be controlled by remote control signals.

ii. When the handswitch is in the “CW” or “CCW” position, the actuator shall move toward the appropriate end-of-travel limit switch. Placing the selector switch in the “Stop” position shall stop the actuator travel.

2.19 INLET FILTER AND SILENCER

A. The manufacturer shall provide a combination inlet filter/silencer for each blower as shown on the drawings and specified herein. Inlet filter/silencers shall be of the free standing, flanged, removable cartridge filter type with attached silencing section capable of a minimum 20 dBA noise attenuation on the midrange octave band (500 to 1000 Hz). Filters shall be constructed of mild steel with polyester powder coated interior and exterior (no liquid or oil-based paint). The filter silencer housings shall be single-stage, cartridge-style, and suitable for outdoor service. Flanges shall be 125# ANSI flange, sized to match blower inlet piping as shown on the drawings.

B. Maximum clean filter pressure drop of the inlet filter/silencer with the elements installed shall not exceed 2-inches WG (0.07 psi) at the design airflow specified in Paragraph 2.02 when measured at the filter silencer outlet. Maximum pressure drop with dirty inlet filters shall be 12-inches WG (0.43 psig) at the design airflow specified in Paragraph 2.02 when measured at the filter silencer outlet. Filter silencer pressure loss rating shall include total restriction, including losses induced by filter housing and filter elements.

C. Filter element face velocity shall not exceed 75 fpm at rated flow, and allowable final differential pressure shall be rated not less than 12-inches WG.

D. Filter medium shall be synthetic, self-supporting, not require a support scrim, and shall not be affected by relative humidity. Filters shall have a minimum efficiency of 98% at 10-micron (nominal). Filter element changes shall not require hand tools and filter element weight shall not exceed 25 lbs. Filter elements shall be cleanable.

E. Filter silencer shall be Endustra Tri-Vent® TZ09 Series Side Outlet w/ Enduralast® Hi-Flow Synthetic Medium or approved equal.

2.20 SPARE PARTS

A. The blower manufacturer shall submit a list of recommended spare parts with long lead items clearly identified.

B. The blower manufacturer shall provide spare parts only for items that will be consumed during startup and testing including sufficient quantities of recommended lubricants.

C. One spare filter element shall be provided for each blower intake filter/silencer.

2.21 PAINTING

A. Blowers, base, and motor shall have prime and finish painting done at the factory using the manufacturer's premium grade paint specifications. Paint system shall be submitted for approval with the shop drawings. A color chart shall be submitted with the shop drawings for Owner selection of color for the blower and motor.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All equipment specified herein shall be installed in accordance with the manufacturer's instructions and checked by the respective manufacturers' representative, in conformity with the applicable sections of this specification. After installation, the equipment shall be aligned and adjusted as required for proper operation.

3.02 SHOP TEST

A. Factory testing of the blowers and components prior to shop performance tests is required. Impellers shall be statically and dynamically balanced and over-sped to 115% of rated speed. Dimension checks shall be made throughout fabrication.

B. Shop running and performance tests for each blower shall be made by the manufacturer and certified curves and reports shall be submitted for approval.

C. After approval of preliminary performance tests, each blower shall be factory performance tested in accordance with the most recent edition of the ASME Power Test Code for Centrifugal Compressors and Exhausters (PTC-10) and as specified herein. Test results shall be reported in accordance with the same code and as specified herein and the results submitted prior to shipment.

D. Factory performance tests are to be conducted with the job specific motor where possible. Calibrated shop motors are acceptable for the witness test according to the most recent edition of the ASME Power Test.

E. The factory performance tests shall be conducted for each blower to demonstrate compliance with all performance requirements. Performance tests shall include a minimum of six (6) points to determine the blower flow-pressure-horsepower characteristic with inlet valve wide open over the full range of specified conditions. Test points shall include points to define the blower surge limit (with inlet modulating valve wide open). Tolerances allowable in testing shall be as approved by the Engineer.

F. A calibrated torque meter shall measure the shaft input horsepower as per Paragraph 4.35 of the Code to verify shaft power draw measurements. Compressor net delivered flow rate and discharge pressure shall be guaranteed with no negative tolerance. There shall be no other tolerances or measuring uncertainties used in reporting test results (i.e., the tests shall be reported with ±zero percent tolerance).

1. The capacity of the blower shall be defined as per Paragraph 4.26 of the ASME PTC-10 Power Test Code. Specifically, capacity is defined as, "the net rate of flow compressed and delivered, expressed in terms of cubic feet per minute at the prevailing inlet temperature and pressure. It shall be measured in a suitable manner to exclude effectively all external leakage losses from sources such as shaft seals." That is, air flow shall be measured on the discharge side of the compressor at zero percent tolerance.

2. Complete instrumentation layout and manufacturer's information for all instrumentation used during testing shall be submitted including the arrangement and device for flow measurement, conversion tables/graphs, and accuracies over the specified flow range. All test equipment shall be calibrated and certified by an independent test agency no more than twelve (12) months prior to the test date. Certificates shall show the stability of calibration over a period of at least one year per ISO 9001, Paragraph 4.1.1.

3. Velocity vibration versus frequency levels shall be recorded within 10-1,000 and 10-10,000 Hz frequency range.

G. In case of failure of any unit to meet the test requirements, the manufacturer, at their own expense, shall make such alterations as are necessary and the tests shall be repeated without additional cost to OWNER until the equipment is satisfactory.

H. The Supplier shall prepare and submit test results, performance curves, and all calculations with a statement certifying that shop tests were successfully conducted in accordance with the test requirements and that all specified performance conditions were demonstrated for each blower system. Certified performance curves based on the results of the shop performance test shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity, as well as the design criteria specified in Paragraph 2.02, at the actual blower speed for each point. SCFM shall be plotted against pressure at both standard and design conditions, and the curve shall show standard horsepower draw over the range of SCFM flow rates.

I. The blower control panel shall be fully tested prior to shipment, including a test of all alarm and trip functions.

3.03 FIELD TESTS

A. Field running tests shall be conducted by the factory service people with assistance of the Contractor.

B. Running tests shall be conducted under actual operating conditions for a period of not less than 8 hours for each blower. Running tests shall demonstrate that the blower is free from all objectionable vibration and noise and overheating throughout the entire range of specified operation. Initial running tests shall demonstrate that all instruments, controls, and protective shutdown interlocks function properly.

C. Each blower shall be run for 4 hours at full load and for 4 hours just above surge. Temperature and vibration readings for all monitored points shall be recorded after 4 hours and at the conclusion of the 8-hour run period for the operating blower(s). Any shutdown of the blower(s) during the test periods shall be recorded and the cause noted. Any defects or operating problems found during running tests shall be promptly corrected.

- END OF SECTION -

SECTION 11230

LOW SPEED SUBMERSIBLE MIXERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install low speed submersible, axial mixers suitable for mixing of activated sludge mixed liquor suspended solids (MLSS) at the locations shown on the Drawings and as specified herein. Mixers and appurtenances shall be designed for continuous submergence under water without loss of watertight integrity to a depth of 50 feet. Mixers shall be able to be raised and lowered and shall be easily removable for service without the need for personnel to enter the tank. All mixers shall be supplied by the same manufacturer.

B. In addition to providing mixing of MLSS, the mixers shall be designed to provide uniform horizontal flow through the oxidation ditch configuration, which includes floor-mounted fine bubble membrane disc diffusers. Sufficient horizontal mixing shall be supplied to maintain the minimum velocities shown in the mixer schedule in Paragraph 2.02 over a range of 0.0 to 3.0 standard cubic feet per minute (scfm) per diffuser based on the diffused aeration system shown on the drawings and specified in Section 11439. The Contractor shall coordinate with both the submersible mixer and fine bubble diffused aeration system manufacturer to ensure appropriate mixer and diffuser compatibility including mixing energy supplied and appropriate clearances between the mixers and diffused aeration equipment.

C. Equipment shall be provided in accordance with the requirements of Section 11000, Equipment General Provisions.

1.02 SUBMITTALS

A. Shop Drawings shall be submitted in accordance with the submittal requirements specified in Section 01300 - Submittals, Section 11000 - Equipment General Provisions and as specified below

B. Spare parts list.

C. The weight of each mixer including: motor, double reduction gearbox, shaft and impeller.

D. Complete motor data including size, make, type and characteristics of the electric motor along with wiring diagrams.

E. Manufacturer’s recommended installation and start-up procedures

F. Certified factory tests.

G. Mixer and mixer installation placement dimensional drawings, indicating orientation of mixer, depth of mixer in tank, and minimum distance from tank walls, tank floor and diffused aeration equipment.

H. Construction installation details

1.03 WARRANTY AND GUARANTEE

A. Warranty and Guarantee shall be as specified in Section 11000.

1.04 QUALITY ASSURANCE

A. The materials covered by the Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per manufacturer's recommendations.

B. All materials shall be new and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the units are to be subjected and shall conform to all applicable sections of these specifications. All parts of duplicate mixers shall be interchangeable without modification.

C. The manufacturer shall have mixing equipment of comparable capacity in successful operation in oxidation ditches for a minimum period of 15 years.

D. All equipment in this Section shall be furnished by a single supplier. The Contractor shall be responsible for the coordination and proper operation of the entire system. Equipment shall be fabricated, assembled, erected, tested and placed in proper operating condition in full conformity with the Drawings, Specifications, instructions and recommendations of the equipment manufacturer.

E. The work of this Section shall be completely coordinated with the work of other Sections. Verify at the site both the dimensions and work of other trades adjoining items of work in this Section before fabrication and installation of items herein specified. Field measurements shall be taken at the site to insure proper fitting of all items.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Each mixer shall be a submersible, direct-drive or close-coupled gearbox, axial mixer as manufactured by Xylem/Flygt or Sulzer-ABS. Being named in this specification does not exempt the Manufacturer from meeting the performance requirements specified herein.

B. The layout and design of the mixer and fine bubble diffused aeration system, including piping and supports, in the contract drawings are based on mixer equipment manufactured by Xylem. Any changes in design including but not limited to structural supports, piping systems, electrical systems or controls resulting from the use of equipment from other manufacturers shall be the sole responsibility of the Contractor. Any redesign for substitute equipment shall be submitted for the Engineer's review prior to fabrication or installation.

2.02 Mixer Schedule

Location	**Aeration Basin 1**	**Aeration Basin 2**
Total Number of Mixers	4	4
Minimum Velocity, feet per second	1.08	1.18
Xylem/Flygt Model No.	4320	4320
Mounting Arrangement	Guide-Bar	Guide-Bar
Tank/Channel Floor Elevation[1], ft	100	100
Operating Platform Top Elevation[1], ft	116	116
Max. Water Surface Elevation[1], ft	114	114
Min. Water Surface Elevation[1], ft	112.5	112.5
Number of Blades	3	3
Maximum Propeller Diameter, in	98	98
Maximum Propeller Speed, rpm	35	46
Power Uptake/Mixer, kW	3.0	5.8
Mixer Motor Rated Power, kW	8	8
MLSS Concentration, mg/L	2,000 – 5,000	2,000 – 5,000

[1]Approximate elevations based on NGVD29 + 100 (Plant Datum). The Contractor shall confirm final elevations and dimensions with the manufacturer

2.03 MATERIALS

A. The mixer and all related equipment shall be designed for the wastewater applications specified herein and shall be suitable for continuous operation underwater to a depth of 50 feet without loss of watertight integrity. The mixer shall be direct-drive, axial-type construction and shall be supplied with a tripod mounting system and mast assembly including integral sliding guide bracket of the mixer manufacturer's design matched to the mixers being supplied.

B. Mixer stator housing shall be of grey cast iron, ASTM A-48 Class 35B with smooth surfaces devoid of blow holes or other irregularities. All cast iron surfaces coming in contact with the mixed liquor suspended solids (MLSS) shall be protected by a factory applied spray top coat of oxiran-ester paint finish on the exterior of the mixer.

C. All hardware shall be made of 316 stainless steel.

D. The propeller shall consist of 316 stainless steel or fiberglass reinforced polyurethane blades, each integrated with stainless steel shaft for mounting in a cast iron hub. Each blade shall be removable for ease of installation and shall be mounted into a socket in the side of the hub. The propeller shaft shall be bolted axially to the hub. The propeller blade shape shall have a non-clogging, back-swept design which starts at the hub leaving no part of the shaft exposed. Propellers shall be dynamically balanced. The propeller shall be capable of handling solids, fibrous materials, heavy sludge, and other matter found in normal wastewater applications.

E. The propeller shaft shall be made of ASTM AISI 431 or 4140 stainless steel or comparable.

2.04 MECHANICAL SEALS

A. For direct-drive mixers, each mixer shall be provided with three seals to separate the various parts of the mixer. The seals shall require neither maintenance nor adjustment.

1. The outer seal on the propeller shaft shall be a mechanical seal made of corrosion resistant cemented carbide (WCCR). The seals shall operate in an oil reservoir that hydrodynamically lubricates the seal faces at a constant rate. Only the seal faces of the outer seal shall be exposed to the mixed media.

2. The inner seal on the propeller shaft shall be a nitrile rubber lip seal isolating the propeller shaft oil chamber from the gear box oil chamber.

3. The third seal shall be a Viton rubber lip seal mounted on the motor shaft to isolate the gear box oil chamber from the stator housing.

4. Each mixer shall have an oil chamber for the shaft sealing system, and a second separate oil chamber for the gear box. Plugs for drainage and inspection of the oil shall be easily accessible from the outside.

B. For mixers with gearboxes, each mixer shall be provided with a triple seal system consisting of one (1) mechanical seal on the outer side, one mechanical seal on the inner side and one (1) radial shaft seal in-board of the inner mechanical seal. Each shall work independently of the others.

1. Both the stationary and rotating faces of the outer mechanical seal shall be industrial duty silicon carbide. The stationary face of the inner mechanical seal shall be silicon carbide and the rotating face silicon carbide.

2. The seals shall not require routine maintenance or adjustment and shall not be dependent on the direction of rotation for proper sealing. The seal system shall not rely upon the mixed media for lubrication and shall not be damaged when the mixer is run dry.

3. The primary mechanical seal shall be protected from interference by particles in the waste water, including fibrous materials, by an active Seal Protection System integrated into the propeller. The back side of the propeller shall be equipped with a sinusoidal cutting ring, forming a close tolerance cutting system with the lower submersible motor front cover. This sinusoidal cutting ring shall spin with the propeller, providing a minimum of 132 shearing actions per revolution. Particles or fibrous material which attempt to lodge behind the propeller or wrap around the mechanical seal shall be effectively sheared by the active cutting system into particles small enough to prevent interference with the mechanical seal. The Seal Protection System shall operate whenever the mixer operates and shall not require adjustment or maintenance in order to function.

4. The oil chamber located between the outer and inner mechanical seals shall hold a sufficient quantity of oil to provide lubrication and cooling for the shaft seals. The oil shall also act as a sensing medium for the seal monitoring system to detect the presence of moisture.

5. The integrity of the mechanical seal system shall be continuously monitored during mixing operation and standby time. An electrical probe shall be provided in a sensing chamber positioned between the primary and secondary mechanical seals for detecting the presence of water contamination within the chamber. The sensing chamber shall be filled with environmentally safe non-toxic oil. A solid-state relay mounted in the mixer control panel or in a separate enclosure shall send a low voltage, low amperage signal to the probe, continuously monitoring the conductivity of the liquid in the sensing chamber.

2.05 BEARINGS

A. For direct-drive mixers, the mixer shaft shall rotate on at least three (3) heavy duty permanently lubricated bearings. The main bearing shall be an angular contact bearing to take up axial loads. One single row angular ball bearing shall be provided to take up axial and radial loads, and one cylindrical roller bearing shall be provided to take radial loads. The bearings shall be pre-loaded by a bearing loading nut located at the upper end of the motor shaft in order to reduce shaft deflection and increase bearing and seal life. The inner bearing shall be single row deep grove ball bearing and the main bearing a spherical roller bearing.

B. For mixers with gearboxes, the motor shall rotate on two (2) high quality permanently lubricated bearings. Inboard bearing shall be of double row angular contact design and sized to transfer all radial and axial loads to the mixer housing. The rear bearing shall be of deep groove ball design preloaded with a wave spring washer. The propeller shaft shall rotate on two (2) high quality bearings. Propeller side bearing shall be of self-aligning roller design and sized to transfer all radial and axial loads to the gearbox housing. The gear side bearing shall be of cylindrical roller design. The bearings from the gearbox second stage shall be of a taper roller design.

C. Bearings shall be designed to carry all radial and axial thrust loads and shall have a minimum AFBMA B 10 life of 100,000 hours.

2.06 GEARBOX

A. Gearboxes shall be two or three-stage helical-type equipped with high precision, low-loaded gears. The motor shaft shall be provided with an integral driving gear. Single reduction gear units are not acceptable.

B. The motor shaft shall be integral to the first stage reduction and the propeller shaft shall be integral to the third stage reduction. A moisture sensor shall be installed in the gearbox oil chamber to monitor water ingress.

C. The intermediate shaft shall rotate in two spherical roller bearings and contain a second driving gear. The propeller shaft shall contain the second driven gear and rotate in one single row and one double row angular contact ball bearing or roller bearing.

2.07 MOTORS

A. The motor shall be a high efficiency synchronous speed permanent magnet type housed in an air filled, watertight chamber. The motor is to be purpose built for underwater operation by the mixer manufacturer. The motor shall be directly connected to the propeller. The motor efficiency shall be tested in accordance with standard 60034-30-01 for international efficiency and meet class IE3 levels at a minimum. Motors shall be rated as follows:

	Aeration Basin 1	**Aeration Basin 2**
Rating	460V, 3 ph, 60 Hz	460V, 3 ph, 60 Hz
Rated Ouput, kW	8	8
Speed, rpm	1800	1800
Insulation	Class H	Class H
Explosion Proof	No	No
Inverter Duty	No	No
Minimum Service Factor	1.15	1.15
Motor Winding Temperature Switches	Yes	Yes
RTDs	No	No
Cooling Jacket	No	No

B. The stator windings and stator leads shall be insulated with moisture resistant Class H (356°F) insulation. The stator shall be trickle impregnated with Class H varnish and shall be press fitted into the stator housing.

C. The motor shall be capable of an unlimited number starts per hour.

D. Mixers shall be provided with a motor protection relay (Mini-cas unit or equal). Mixer monitoring shall provide dual function monitoring for both over-temperature via bi-metal, thermistor and seal failure via moisture sensor or float switch. Only low voltage leakage system allowed. Modules shall provide independent 100 ma, 24 VAC or 5A, 120 VAC rated Form C outputs for both over-temperature and seal failure. Module must have a 24-120 VAC input power range, a 2.8-watt power consumption, and must be UL labeled. Motor protection relay shall be provided in a NEMA 4X, 316 SST box, suitable for mounting to a Unistrut stand next to the junction box used for terminating the mixer power cables.

2.08 MOTOR CABLE

A. The mixer manufacturer shall provide the power and control cables between the mixer and the local disconnect switch or junction box, (see Drawings) and shall be responsible for reviewing the electrical drawings as necessary to determine the required cable length. All mixers for the same mixing application shall be provided with the same length of cable. No splices shall be allowed unless specifically indicated on the Drawings. Cables shall be PVC or oil resistant chloroprene rubber jacketed type SPC cable suitable for submersible mixer applications and shall be sized according to NEC and ICEA standards. Stainless steel strain relief connectors shall be furnished for all cables.

B. The power cable shall be a heavy duty 4 screened cores motor power cable with four twisted pair screened control cores with a conductor insulation rating of 90°C. The cable shall be chemical resistant within a pH range of of 3 to 10 and shall be ozone, oil, and flame resistant. The cable shall be suitable for use in wastewater up to 70°C.

C. The cable entry water seal design shall insure a watertight and submersible seal without specific torque requirements. The cable entry shall be comprised of a single cylindrical elastomer grommet, flanked by stainless steel washers all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable. The assembly shall bear against a shoulder in the mixer assembly. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate gaining access through the mixer assembly. The junction chamber containing the terminal board shall be sealed from the motor by an elastomer compression seal O-ring. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to the terminal board and thus perfectly leak proof. Each mixer shall be equipped with separate terminal board that totally isolates the incoming power supply from the mixer motor.

2.10 MIXER MOUNTING SYSTEM

A. The mixer mounting system shall be configured to allow for easy lifting and lowering of the mixer by crane or davit crane up the guide bar and out of the tank for inspection or servicing without draining the tank. The mixer mounting system shall be comprised of a fixed stainless steel tripod or concrete pedestal mounted to the floor with 304 stainless steel guide bar. Lifting chain or cable shall be overhead rated.

B. Bottom mounted tripod shall be constructed of minimum 304 stainless steel. The tripod and guide bar shall be able to fully support the mixer's weight and designed to resist all forces on the mixer during operation without deflection or damage. When the mixer is in place, it shall rest on a support arm designed to carry the mixer's full weight and minimize movement from unbalanced or intermittent torsional forces.

C. Cable holders and power cable support grips shall be provided as recommended by the Manufacturer.

D. Concrete pedestals shall be hydro-dynamically shaped. A coupling mechanism shall positively lock the unit in place to prevent flow induced vibrations. A cast slide bracket shall be an integral part of the mixer unit. The entire weight of the mixer unit shall be guided by a single bracket that must be able to withstand all forces created by the mixer.

2.11 SURFACE PREPARATION

A. The mixer manufacturer shall be responsible for surface preparation, priming, and finish coating of ferrous metal components prior to shipment in accordance with Section 09900. Stainless steel, bronze, and nonmetallic surfaces shall not be coated. Coat machined or bearing surfaces and holds with protective grease.

2.12 SPARE PARTS

A. Spare parts shall be provided in accordance with Section 11000, Equipment General Provisions and shall include any special tools required for equipment access and maintenance.

PART 3 -- EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 11000, Equipment General Provisions. Field services shall include the following site visits:

Service	**Number of Trips**	**Number of Days/Trip**
Installation and Testing	2 (one per tank)	1
Startup and Training	1	1
Services after Startup	1	1

3.02 SHOP TESTING

A. Shop testing shall be in accordance with Section 11000, Equipment General Provisions and with the following additional requirements:

1. Impeller, motor rating and electrical connections shall be checked.

2. A motor and cable insulation test for moisture content or defective insulation shall be made.

3. Prior to submergence, the mixer shall be run dry to establish correct rotation and mechanical integrity. After the run-dry test, the insulation test shall be performed again.

4. The mixer shall be run for 30 minutes submerged, a minimum of six (6) ft. under water.

3.03 FIELD TESTING

A. Mixers shall be checked for balance by the equipment manufacturer's representative while operating unsubmerged after mixer installation. Any issues relating to vibration and noise shall be corrected by the Contractor at no expense to the Owner.

B. Mixer testing shall be performed with plant effluent water prior to introduction of wastewater into tanks. The Owner shall provide plant effluent water at no charge to the Contractor. Contractor shall provide all equipment, including pumps, and shall pay all costs to pump or plant effluent water to the Aeration Tanks for field tests of the mixers at an appropriate flow rate to fill the Aeration Tank within 48 hours in coordination with field testing of the fine bubble aeration equipment. Connection to a plant effluent hydrant will not be acceptable. Tanks shall be filled to maximum water levels.

C. An equipment performance test shall be conducted on the installed mixers after wastewater is added to the tank in order to demonstrate power consumption. The power consumption shall be a maximum 95 percent of the motor nameplate rating.

   1. All mixers in the tank shall be checked with amperage and voltage measurements to assure that all mixers are operating at the same power draw. With all units operating, the transient power consumption of each size mixer as recorded by the wattmeter shall not vary more than plus/minus 5 percent from the average value for the two (2) units.

   2. The mixers shall be operated for a minimum of 24 hours without overheating, excessive vibration or overloading. Any deficiencies in mixer performance shall be corrected by the Contractor at no cost to the Owner.

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SECTION 11439

FINE BUBBLE DIFFUSED AERATION EQUIPMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials, tools and equipment necessary for demolition and removal of the existing fine bubble membrane diffused aeration equipment including diffusers, manifolds, diffuser header pipes, supports, purge systems, and related items in the existing Aeration Tanks as shown on the Contract Drawings and as specified herein. Unless anchoring devices are noted to remain following demolition, the Contractor shall remove and/or burn back anchors to ½-inch minimum below the surface and plug all anchor bolt holes with epoxy resin binder. If anchoring devices are stainless steel then the anchors may be cut and removed to the top of concrete surface without applying epoxy resin binder.

B. The Contractor shall furnish all labor, materials, tools and equipment necessary for supply, installation, testing, and placing into satisfactory operation new fine bubble membrane diffused aeration equipment including stainless steel drop legs, stainless steel to PVC transition coupling, PVC manifold and distributor pipes, diffuser holders, diffusers, stainless steel supports, purge systems, and related items in the existing Aeration Tanks as shown on the Contract Drawings and as specified herein.

C. The diffused aeration equipment shall be provided complete with all accessories, special tools, spare parts, mountings, anchor bolts, and other appurtenances as specified and as may be required for a complete and operational installation. All diffusers shall be installed to within 1/8-inch of the same elevation in all tanks. All air piping, tees, expansion fittings, manifolds, diffuser header pipes, purge systems, supports, diffusers, diffuser elements, orifice plugs, and all other necessary equipment shall be supplied new by the Manufacturer. All diffuser membranes shall be manufactured by the same supplier and at the same location to ensure similar properties for all membrane diffusers to be installed.

D. The membrane diffused aeration equipment shall be supplied by Sanitaire (Xylem) or Aquarius Technologies LLC. Being named in this specification does not exempt the Manufacturer from meeting the performance requirements specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Division 1 – General Requirements

B. Section 01520 – Maintenance of Plant Operations During Construction

C. Division 5 – Metals

D. Section 11000 – Equipment General Provisions

E. Section 15013 – Steel Pipe for Low Pressure Process Air Service

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Shall be as specified in Section 01090 – Reference Standards.

1.04 SUBMITTALS

A. The Contractor shall submit Shop Drawings, Operation and Maintenance Manuals and other information as specified in accordance with Section 11000 – Equipment General Provisions and Section 01300 – Submittals. Shop Drawings shall include complete erection, installation, and adjustment instructions and recommendations. Detailed layout drawings for the diffused aeration system in each of the existing Aeration Tanks shall be based on existing tank dimensions, floor slab elevations, and obstructions as field verified by the Contractor. After the tank is emptied, The Contractor shall measure floor slab elevations at a minimum of eight (8) locations in each tank to confirm the floor slab elevations shown in the Contract Drawings. The Contractor shall field verify existing tank dimensions and locations of all obstructions, including but not limited to: columns, walls, piping, supports, and drain sumps. The Contractor shall provide field verified information to the Manufacturer before Shop Drawings are prepared and submitted.

B. The Manufacturer shall guarantee the oxygen transfer efficiency of the equipment. Certified oxygen transfer efficiency and headloss curves shall be submitted for identical diffusers based on previous testing conducted in accordance with the latest revision of ASCE Standards for the design submergence and range of operating airflows specified herein.

C. The Manufacturer shall submit Quality Assurance / Quality Control documentation for the manufacturing process of the diffused aeration system including the membrane diffusers themselves. Protocols detailing primer and solvent storage and application, including torque and impact testing to ensure proper pod to pipe attachment shall be included. Details of the method of attachment of the holder to the distributor piping shall be included.

D. The Manufacturer shall submit a performance guarantee and two (2) year warranty as specified herein.

E. The Manufacturer's installation instructions shall be submitted prior to shipment of the diffuser equipment. Installation and storage instructions shall be complete and shall include anchoring, leveling, fastening, inspection, provisions for expansion/contraction, and additional instructions as required.

1.05 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall arrange for the Manufacturer to furnish the services of a qualified technical representative with at least three years of experience, who is regularly involved in the inspection, installation, startup, testing, operation, and maintenance of fine bubble aeration systems. The Manufacturer's technical representative(s) shall:

1. Witness installation procedures and check installation. The Contractor shall conduct all field tests described in Subsection 3.02 including a pull test for each anchor bolt.

2. Witness and check operation at startup.

3. Assist the Contractor in performing field testing and preparing a written report as specified below.

4. Troubleshoot, document, and correct any equipment problems that are noted during initial operation.

5. Submit written certification signed by the Manufacturer's technical representative(s) and a Manufacturer's corporate officer, Vice President or higher, that the system has been properly installed, tested, and adjusted and that the system operates as required, including dates of field tests and a listing of all persons present during the tests.

6. Investigate and correct any equipment problems that may arise during the warranty period of the equipment.

7. Instruct the Owner's personnel in proper operation and maintenance of the equipment.

B. Such services shall be furnished at no additional cost to the Owner and shall entail a period of not less than 4 days and a minimum of 2 site visits, for a minimum of two 8-hour days per aeration tank.

C. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the Manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

D. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

E. The Manufacturer's representative shall sign in and out at the Engineer's Field Office on each day and shall comply with Owner requirements for visiting the site.

F. A written report covering the representative's findings and installation approval shall be submitted to the Engineer covering all inspections and outlining in detail any deficiencies noted.

1.06 QUALITY ASSURANCE

A. The materials covered by these Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment.

B. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Contract Drawings and operated per the Manufacturer's recommendations.

C. All material shall be new and both workmanship and materials shall be of the very best quality, totally suitable for use with compressed air for the service conditions indicated in the Contract Documents.

D. All components of the fine bubble diffuser system shall have been used successfully by the Manufacturer in previous installations. The Manufacturer shall note any new or changed components on the submittal drawings for Engineer approval.

E. Design of support systems, system for expansion and contraction, and diffuser assemblies shall be the full undivided responsibility of the equipment manufacturer. Layout of the equipment in the reactor shall be the responsibility of the equipment Manufacturer and shall meet the equipment requirements specified herein.

F. The diffuser system including but not limited to drop pipes, manifolds, distributors, and supports shall be designed to resist all forces imparted by mixing equipment and internal flows (including but not limited to influent and return activated sludge (RAS)) and other forces that may be present during basin operation. Design of supports for forces including those generated by operating mixers shall be the responsibility of the diffused aeration system Manufacturer. The Contractor shall coordinate between the mixer and diffused aeration equipment manufacturers to ensure that the diffuser supports are fully compatible with the selected mixing equipment. Additional cross bracing and/or struts shall be furnished by the diffused aeration system Manufacturer and installed by the Contractor where necessary. The Contractor shall coordinate between the mixer and diffused aeration equipment manufacturers to ensure that the diffuser supports are fully compatible with and adequate clearances are provided for the selected mixing equipment. Clearances between diffused aeration equipment and mixers and piping shall be included in the shop drawings submitted by the diffused aeration equipment Manufacturer.

G. The system for expansion and contraction and all diffuser system components shall be designed for a temperature range of a minimum of 10°F (diffuser distributor out of service and exposed) to a maximum of 140°F (diffuser in operation with limited submergence of the diffusers).

H. The membrane fine bubble aeration system shall be supplied as a complete system from a single manufacturer.

1.07 HANDLING AND STORAGE

A. Special care shall be exercised during delivery, handling, and storage of equipment and material to prevent damage, degradation of materials, and fouling. Delivery shall be scheduled by the Contractor to minimize time materials are stored on site. Materials shall not be stored on site for more than 90 days. In the event the storage time exceeds 90 days, the Owner can require storage in a bonded, climate controlled facility at no expense to the Owner.

B. Delivery, handling, and storage of the piping and equipment shall be in accordance with Manufacturer's recommendations and as specified in Division 1 – General Requirements.

C. All PVC piping, diffuser holders and membrane diffusers shall be completely protected from exposure to sunlight by storage indoors or under a canopy. Storage under tarps or plastic is not permitted to avoid exposing equipment to high temperatures.

D. All parts of the air diffusion equipment shall be shipped to the job site adequately palletized and protected from breakage and dirt.

E. All PVC and stainless steel piping shall be crated and supported in a wood framework. All loose fittings, pipe supports, etc., shall be adequately boxed and palletized. All equipment shall remain palletized and boxed until the time of installation.

1.08 WARRANTY AND GUARANTEE

A. The membrane material shall be proven to be effective in fine bubble aeration applications with at least five installations with not less than three years' experience each of satisfactory performance. The Manufacturer shall provide a list of successful applications with contact information in the equipment submittal. Materials/diffusers that do not comply with performance history requirements will not be accepted.

B. If any materials are found to be defective within two years of the date when the diffused aeration equipment is placed into service, the Manufacturer shall pay all labor and materials costs for removal of the defective materials and replacement with satisfactory materials. Defective materials shall include improperly assembled diffuser distributor. The Manufacturer shall provide all labor and material to replace the header pipes where there is separation or leaks between the diffuser holder and header piping. If within two years after the date diffused aeration equipment is placed in service, installation is found to be unsatisfactory, installation shall be redone by the Contractor at no additional cost to the Owner. Unsatisfactory installation shall include improperly installed anchor bolts that cause piping to become unattached and to separate resulting in leaks. The warranty period of two years will extend from the date that equipment is placed into service or after correction of defective installation.

PART 2 -- PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Aeration Tanks

1. The membrane fine bubble diffuser system shall be used in the activated sludge process to transfer oxygen into mixed liquor. Methanol, ethanol, acetic acid, sodium acetate, corn syrup, glycerol, Micro-C™, anionic polymer, cationic polymer, solids recycle streams, sodium hypochlorite, alum, ferric chloride, polyaluminate chlorides, sodium aluminate, and fats, oils and grease may also be present in any stage of the aeration tanks. The list of possible constituents in the wastewater is not limited to this list. The system manufacturer shall ensure that all materials are compatible with these and other potential constituents found in wastewater.

2. The system Manufacturer shall guarantee diffuser system performance for specified transfer efficiency and headloss.

3. The diffusers and diffuser system shall operate efficiently and effectively over the range of 0.5 to 3.0 scfm per diffuser.

4. Membrane diffuser transfer efficiency and headloss requirements at 11.5 feet of diffuser submergence at various diffuser airflow rates and the specified diffuser densities, expressed as tank surface area / total diffuser area (AT/AD), shall be as follows:

Airflow/Diffuser (scfm)	Maximum Headloss Across Orifice Plus Diffuser (in. H_2O)	Minimum Standard Oxygen Transfer Efficiency (%)	
		AT/AD = 5.0	AT/AD = 7.9
0.50	10	29.4	29.0
1.25	13	26.8	26.0
2.25	18	25.2	24.2
3.0	24	23.9	23.3

5. Standard oxygen transfer efficiency shall be based on a liquid temperature of 20°C, oxygen saturation value and transfer characteristic (KLa) equal to that of clean tap water at 20°C, and initial dissolved oxygen concentration of zero mg/l, an alpha factor of 1.0, a beta factor of 1.0, and a temperature correction factor (theta) of 1.024.

6. No tolerance shall be allowed for required minimum oxygen transfer efficiency. Tolerance for measured headloss shall be -15 percent and +10 percent.

7. The Manufacturer shall provide control orifices sized for the required headloss.

8. The Contractor shall field verify the elevation of the tank floors and the dimensions in each tank prior to installation of the diffusers and notify the engineer if the tank floor elevations or tank dimensions deviate from what is shown on the Contract Drawings. The Contractor shall schedule submittal of Shop Drawings for diffused aeration equipment after field verification of tank dimensions such that diffusers are laid out based on actual tank dimensions.

2.02 EQUIPMENT REQUIREMENTS

A. Layout of blank diffusers in the diffuser grid shall be submitted for Engineer review and shall provide as uniform a pattern of active diffusers as possible.

B. The Contractor shall furnish a complete membrane fine bubble aeration system in each of the two Aeration Tanks. The Contractor shall furnish drop pipes, manifolds, diffuser distributor, diffuser saddles and diffusers in the tanks as follows:

Parameter	Aeration Tank 2
	Grid Type A
Number of Grids of this Type	6
Approximate Zone Dimensions Length x Width (feet)	70 x 34
Drop Pipe Diameter (inch)	12
Manifold Diameter (inch)	10
Distributor Diameter (inch)	4
Number of Rows (Minimum)	18
Diffuser Saddles per Row	66
Diffusers per Row	66
Diffuser Saddles per Grid	1,188
Diffusers per Grid	1,188
Spare Saddles per Grid	0
Total Diffuser Saddles per Basin	7,128

Parameters	Aeration Tank 1
	Grid Type B
Number of Grids of this Type	6
Approximate Zone Dimensions Length x Width (feet)	70 x 34
Drop Pipe Diameter (inch)	12
Manifold Diameter (inch)	8
Distributor Diameter (inch)	4
Number of Rows (Minimum)	14
Diffuser Saddles per Row	54
Diffusers per Row	54
Diffuser Saddles per Grid	756
Diffusers per Grid	756
Spare Saddles per Grid	0
Total Diffuser Saddles per Basin	4,536

2.03 MATERIALS OF CONSTRUCTION

A. Stainless steel pipe shall conform to requirements in Section 15013 – Steel Piping for Low Pressure Process Air Service. Stainless steel hardware shall conform to requirements in Division 5 – Metals.

B. All PVC pipe and fittings shall be manufactured from PVC compound with a tensile strength of 7000 psi.

C. PVC resins shall be blended with fillers to achieve a minimum “K” value of 58 for fittings and a minimum “K” value of 64 for pipe.

D. Two parts by weight of titanium dioxide per 100 parts of PVC resin shall be provided in PVC material for air distribution piping, diffuser element holders, and retainer rings to resist ultraviolet (UV) light degradation.

E. All PVC pipe shall perform satisfactorily when subjected to 130°F mean wall temperatures on a long term continuous basis.

F. All solvent welding shall be completed prior to shipment to the site; no field solvent welding shall be allowed except for moisture blow-off piping and the connection of the PVC portion of the drop leg to the manifold.

G. Layout of piping around any obstructions shall be submitted for Engineer review.

H. Solvent welds shall be factory assembled in accordance with ASTM 2855 and tested prior to shipment. Diffuser holders shall be factory solvent welded and ultrasonically staked to the pipe to maximize adhesion. Solvent welds shall be accomplished with solvent cements specifically formulated for use with PVC.

I. 316 stainless steel double nuts or Nylock-type locknuts shall be uses at upper support clamps and anchors to prevent movement due to vibration. 316 stainless steel lock washers and nuts shall be used at the lower support clamps.

2.04 DOWNCOMERS (DROP PIPES)

A. Downcomer piping downstream of the isolating butterfly valve shall be 304L stainless steel in accordance with the applicable requirements in the specifications and shall be furnished by the diffused aeration system manufacturer.

B. Downcomer piping shall be supported from its upper flange connection to the air main and with a minimum of two (2) submerged 304L stainless steel wall supports furnished by the diffuser manufacturer as required to make the piping secure and stable under all conditions.

C. The diffuser manufacturer shall supply a transition coupling from the stainless steel downcomer to the PVC manifold. The transition from the stainless steel downcomer to the PVC manifold shall be within 12 inches of the manifold. Transition couplings shall be a fabricated lug all-stainless steel universal clamp, JCM 168 or equal, or a bolted split-sleeve stainless steel sleeve coupling, Victaulic 231S or equal.

2.05 SUBMERGED MANIFOLDS

A. Air manifold piping shall be Schedule 40 PVC conforming to ASTM D 1784, D 1785, and D 2466 with minimum 1.5% TiO_2 for UV protection.

B. Manifolds shall be fabricated in nominal lengths up to 30 feet. Ends of the manifolds shall be factory solvent welded end caps or plates.

C. Stainless steel supports shall be provided for air manifold piping at a spacing of not more than 8 feet.

1. Material for supports shall be 304L stainless steel.

2. Manifold pipe supports shall be made of minimum 5/8-inch diameter threaded anchor rods, washers, hex nuts, and 12 gauge by 2-inch pipe clamps.

3. Anchor bolts shall be 316 stainless steel, minimum size 5/8-inch diameter with a minimum 3.5-inch embedment.

4. Fabricate manifolds with one 4-inch diameter fixed joint connection to each air distribution header. Each air distribution header shall be anchored to the floor within 7.5 feet of the manifold.

5. Furnish manifolds with minimum Schedule 40 dimensions when stub to manifold connection is reinforced with a solvent welded saddle tee. Furnish manifolds with Schedule 80 dimensions when stub connection is unreinforced.

6. Manifold supports with a pipe centerline of 22 inches or higher above the tank floor shall require a diagonal stainless steel support strut for added support rigidity.

7. Manifold supports shall provide for plus or minus two inches vertical adjustment.

8. Design manifold, connections and supports to resist thrust generated by expansion or contraction of the air distributors.

D. The invert elevation of the submerged air manifolds and elevation of the top of the diffuser shall be the same in all tanks.

E. The equipment Manufacturer shall supply all manifold flange bolts, nuts, washers, and gaskets. Flanges shall be PVC. Connection hardware shall be minimum 316 stainless steel.

F. Provide PVC manifolds perpendicular to and at the same centerline elevation as the air distributor.

2.06 DIFFUSER HEADER SYSTEM

A. The diffuser header system shall include the header piping (distributors), support stands and provisions for expansion/contraction of piping, factory installed diffuser element holders, anchor bolts, and all necessary connectors.

B. Distributors shall be equivalent to Schedule 40 PVC wall thickness and shall be perpendicular to the air manifold.

C. Diffuser distributor, diffuser holders, and retainer rings shall be manufactured of PVC with minimum 2% TiO_2 added for UV protection.

D. Diffuser holders and retainer rings shall have a minimum wall thickness of 0.12 inches.

E. The diffuser distributor shall connect to the side centerline of the manifolds.

F. The distributor shall be fabricated in sections not exceeding 23 feet in length with sections joined by fixed joints and anchored by guide (sliding) supports.

G. The pipe and piping grid design and installation shall withstand the normal system operating pressures and temperatures as well as all surges during startup periods.

H. Corners and ends of the grid shall be equipped with easily removable caps or plugs for cleanout of the grid piping interior.

I. The header system shall consist of fixed joints between header pipes and guide supports which allow movement of the pipe with changes in temperature. Support spacing shall not exceed 7.5 feet.

1. The fixed joint shall consist of a spigot section with grooves solvent welded to one end of a header, a threaded socket section with splines solvent welded to the mating header, an O-ring gasket, and a threaded screw-on retaining ring or shall consist of an O-ring gasket compressed on all four sides plus anti-rotational protrusions on the socket and spigot ends to prevent rotation.

2. The fixed joint shall provide a rigid connection between distributor and shall prevent rotation of either of the pipes. In lieu of the fixed joint described above, flanges shall be used to connect header pipes in accordance with ASTM standards for the specified header pipe.

3. Intermediate guide supports shall consist of a hold-down and sliding mechanism which shall provide a minimum 1.5 in. wide contoured bearing surface with chamfered leading edges to minimize binding of the air header piping. The sliding mechanism shall provide minimum resistance to movement of the header pipe.

4. Supports shall be fabricated of Type 304L stainless steel. Distributor pipe supports shall be made of minimum ½-inch diameter threaded anchor rods, washers, hex nuts, and 14 gauge by 1-1/2- inch pipe clamps. The supports shall be designed to provide plus or minus 2 inches vertical adjustment of the header. Adjustment shall be continuous and possible without removing the air piping from the support. The Contractor shall furnish all materials to compensate for any variations in floor slab elevations where fine bubble diffusers are installed.

a. The Contractor and Manufacturer shall be fully responsible for designing, furnishing, and installing supports to withstand all potential forces.

b. Anchor bolts shall be 316 stainless steel, minimum size 1/2-inch diameter with a minimum 3.5-inch embedment.

c. Each support shall be secured to the tank floor with 316 stainless steel adhesive type anchors.

d. The support system shall be designed to withstand a force at least equal to 4 times the buoyant force.

e. The Contractor and Manufacturer shall be fully responsible for adhesive-type anchors used to provide zero pull-out of header support of anchor bolts.

f. The entire system shall be designed, manufactured, and installed in such a manner that all the diffuser elements in all tanks are within ± 1/8 inch of a common diffuser elevation.

g. Air distribution shall be uniform throughout the entire system and shall be uniform over the entire horizontal projected surface of each diffuser element.

h. All air manifolds, diffuser distributor, and diffusers shall be capable of being installed precisely at level and of remaining level under all conditions of operation whether the aeration tanks are full, partially full, or empty.

2.07 DIFFUSER ASSEMBLY

A. Each air diffuser assembly shall incorporate a nominal 9-inch diameter membrane diffuser element with insert and flow control orifice, a diffuser holder and a factory solvent welded or factory installed mechanical air tight connection to the diffuser header system.

B. The membrane diffuser element shall be made from EPDM material with precision die formed slits. Thermoplastic materials such as plasticized PVC or polyurethane will not be accepted.

C. Diffuser shall be a one-piece compression molded part with a minimum thickness of 0.080 inch for nominal 9-inch diameter unit. This part thickness shall limit the maximum tensile stress of the rubber membrane to 10 psi when operating at 2.4 scfm per square foot of membrane media.

The EPDM rubber compound shall have the following minimum characteristics:

Parameter	Design Criteria	ASTM
Base Polymer:	EPDM	
UV Resistance:	Carbon Black	
Specific Gravity:	1.25 or Less	
Ozone Resistance	Pass	D1171
Durometer, Shore A:	58 Point ±5	D2240
Tensile Strength:	1,200 psi minimum	D412
Elongation at Break:	350% minimum	D412
Accelerated Aging		
Max. Compression Set		
@ 23°C, 22 Hrs.	20%	D573
@ 70°C, 22 Hrs.	40%	

D. The membrane shall collapse and seal when aeration system air is turned off. Membrane shall be able to collapse onto the support base when air is not being diffused. Diffusers that require a center bolt to limit membrane deflection will not be allowed.

E. A PVC retaining ring shall be furnished to securely hold and seal the diffuser to the disc holder to prevent air escape at the diffuser disc-sealing gasket interface.

F. The sealing method shall allow the applied sealing force between the sealing gasket and membrane to be varied, with a minimum force of 50 pounds per inch of circumference of the sealing gasket to provide a long-term positive seal and prevent air escape except through the active area of the diffuser.

G. Retainer ring and diffuser element holder shall be provided with a minimum of one complete thread with a minimum cross-section of 1/8 inch for engagement.

H. Diffusers shall be substantially free from any material soluble in sewage containing household industrial wastes of any character and from any loose, unbonded material which may affect their normal and proper operation.

I. All diffusers shall be free of cracks, soft spots, or other defects which may cause unequal air distribution. The diffuser elements shall provide a constant and uniform distribution of the emergent diffused air bubbles across their entire exposed area.

J. Each diffuser assembly shall incorporate a control orifice. The air release of the orifice shall be distributed evenly under the horizontal surface of the diffuser element to meet the operating requirements including pressure, temperature, wastewater characteristics, airflow per diffuser, etc. for the system specified.

K. Orifices shall be of the same diameter and length for all diffusers. Orifices shall be provided free of any shavings, obstructions, or residual solvent weld material.

L. All orifices shall be factory drilled. Orifices shall be examined in the field prior to installation. If any improperly fabricated orifices are found, field testing shall continue until 95 percent of the tested orifices conform to the Specifications. Improperly fabricated orifices and all associated diffuser assemblies or piping shall be replaced by the Manufacturer at no cost to the Owner.

M. Orifices shall be 13/64-inch diameter control orifices unless otherwise required to provide the required headloss across the orifice plus diffuser specified in Subsection 2.01.

N. The diffuser holder shall be suitably solvent welded to the diffuser header at the factory to strict tolerances. Following curing, a sample test piece with at least 4 diffuser holders from each day's production shall be tested for torque and impact resistance. The holder and pipe shall be clamped in a test fixture and tested at a rotational torque and at an impact energy to confirm proper connection of the diffuser holder to the header pipe.

    1. The diffuser element holders shall be attached to the header to resist applied torques of 150 foot pounds about the polar axis of the holder and 100 foot pounds about the longitudinal axis of the holder.

2. The diffuser holder shall be PVC and shall provide for horizontal mounting of the membrane diffuser.

3. The bottom rim and top surface of the diffuser and diffuser holder shall be horizontal. The diffuser holder shall be attached to the pipe with no more than 1 degree angular variation from top dead center. Diffuser tilt shall be field verified by the Contractor as required by the Engineer by use of a level and scale, and witnessed by the Engineer.

4. All diffuser holders and associated piping with tilt in excess of ± 1/8 inch shall be removed by the Contractor and replaced by the Manufacturer without additional cost to the Owner.

5. The diffuser hold-down arrangement shall provide for an airtight seal between the diffuser and diffuser holder such that even after 20 years of operation all air passes through the diffuser.

O. The Contractor shall replace any diffusers which are damaged in shipment or during installation at no additional cost to the Owner.

P. Membrane diffuser holders shall provide complete peripheral edge support for the membrane diffuser element. The diffuser assembly and retaining device shall prevent air escape at the diffuser element-sealing gasket interface. The gasket shall be integral with the diffuser membrane.

Q. Alternatives utilizing a threaded nipple design for attaching diffuser to header will not be allowed.

2.08 PURGE ASSEMBLIES

A. Two mechanisms for purging moisture from the air piping shall be provided.

1. One continuous purge assembly per independent grid shall be provided.

2. One moisture blow-off assembly per independent grid shall be provided.

B. The continuous purge assembly shall consist of an EPDM membrane tube or snap cap diffuser, hose, and 316L stainless steel supports and clamps.

C. Moisture Blow-off Assemblies

1. The moisture blow-off piping shall include all required pipe, fittings, valves and supports.

2. The moisture blow-off assembly shall operate on the airlift principle and shall be designed to remove any liquid that has entered the air piping system.

3. The moisture blow-off assembly shall be located at the extreme corners of each grid.

4. Vertical moisture blow-off piping shall be Schedule 80, minimum 1/2-inch diameter PVC in accordance with ASTM D2467.

5. Vertical piping shall be secured to the tank wall with 316 stainless steel anchors and fasteners. Support spacing shall not exceed 5 feet. Vertical piping shall extend to 18-inches above the tank wall for each access to the purge valve. Provide a tee-fitting at the top of the assembly for clean out and for installing a minimum ½-inch PVC threaded ball valve on the branch of the tee. Final location of the ball valve shall be as approved by the Engineer.

6. The bottom of the vertical purge piping shall connect to a moisture-blowoff tee integral with the aeration grid piping and shall be provided with a factory-welded minimum ½-inch PVC dip tube, which shall remove moisture from the invert of the grid piping.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Unless otherwise shown or specified, all equipment shall be installed in strict accordance with Manufacturers' instructions and recommendations.

B. The Contractor shall replace any diffusers which are broken or damaged in shipment, in relocation, or during installation at no additional cost to the Owner.

C. The Contractor shall be responsible for providing proper storage at no additional cost to the Owner.

D. Diffusers to be stored by the Owner at the end of construction shall be inspected for integrity prior to acceptance for storage.

E. Each tank shall be cleaned by the Contractor to remove all debris from the tank in accordance with Section 01520 to provide for proper installation of the fine bubble diffused aeration equipment.

F. The Contractor shall comply with manufacturer's recommendations after diffusers are installed and before and during placement into operation to ensure that diffusers are maintained in "new" condition and to prevent any sliming or bio-fouling of the diffuser elements.

G. The Contractor shall minimize the time that diffuser membranes, PVC components, and grid piping are exposed to sunlight and/or freezing temperatures by completing installation of piping and diffusers in a tank within three weeks from the installation of the first piping in the tank and shall cover the system with plant effluent water until the system is placed in service. The Owner will provide plant effluent water at no charge to the Contractor. Contractor shall provide all equipment and pay all costs to pump or transport plant effluent water to the tank. If the Contractor’s activities preclude the usage of plant effluent water, the Contractor shall be responsible for all costs associated with providing potable water. The Owner cannot guarantee the quality or solids content of the plant effluent water.

H. Concrete anchors shall not be installed within 6 inches of any concrete expansion joint.

I. Contractor shall clean air header pipe, mains, submains, laterals, blowers, filters and droplegs prior to installing diffuser elements.

J. Contractor shall protect diffuser elements from unpressurized submergence in wastewater.

3.02 FIELD TESTS

A. The Contractor shall conduct the installation and performance tests for the diffuser system as specified herein. Detailed procedures for all field testing shall be submitted with the Shop Drawings. The Owner shall provide plant effluent water at no charge to the Contractor. Contractor shall provide all equipment, including pumps, and shall pay all costs to pump or transport plant effluent water to the Aeration Tanks for field tests of the fine bubble diffusers. In the event that the Contractor's activities preclude the usage of plant effluent water, the Contractor shall be responsible for all costs associated with providing potable water. The tank shall be filled for testing with Contractor provided equipment within a two day period.The Owner cannot guarantee the quality or solids content of the plant effluent water.

B. The Contractor shall conduct pull tests for all diffuser system piping supports and tie-downs to ensure that all supports and tie-downs have a margin of safety of 4 against calculated buoyant forces. The Contractor shall submit details of proposed pull test apparatus and procedures to Engineer for approval.

1. Each support shall be attached to a lever which shall be placed on a fulcrum.

2. A static load shall be applied to the opposite end producing a vertical (or horizontal for wall-mounted supports) extracting force on the support/tie-down equal to 4 times the calculated maximum buoyant forces to which the support/tie-downs will be subjected in normal operation.

3. All supports shall be tested; no exceptions or substitutions shall be allowed.

C. The Contractor shall conduct field leakage tests for all submerged air piping.

1. The procedure shall consist of operating the system under plant effluent water for visual identification of all leaks.

2. All field leakage tests shall be witnessed by the Owner and/or Engineer.

3. All submerged piping shall be installed free of any leaks.

D. The Contractor shall conduct air distribution tests in each tank.

1. Each aeration tank shall be filled with plant effluent water to a depth above the diffusers as directed by the Engineer.

2. The system shall be operated over the full range of operating conditions (0.5 to 3.0 scfm/diffuser). Uniform air distribution to all individual diffusers within the tank shall be verified by visual inspection.

3. If in the opinion of the Engineer there are areas of consistent low or high airflows, then the Contractor shall make all necessary adjustments to correct these deficiencies.

E. The Contractor shall take level measurements for each diffuser during installation to ensure that all membrane diffusers are installed to within 1/8 inch of a common horizontal plane. Field surveying equipment used shall be as approved by the Engineer.

1. A final level check shall be made during air distribution tests.

2. During filling, visual inspection shall be made when the water level is at the top of the diffuser elements to confirm that all diffusers are installed to within 1/8-inch of a common horizontal plane.

3. Prior to startup of each Tank with fine bubble diffusers, and as a condition of acceptance, the Contractor shall provide the services of an independent surveyor, licensed as a Professional Surveyor in the State of South Carolina, to verify the elevations of the installed diffusers in each Tank. Contractor shall adjust elevations based on survey to provide all diffusers at the same elevation to within the specified plus or minus 1/8. Survey shall be completed and elevations shall be per specifications before wastewater may be reintroduced into the Tank.

– END OF SECTION –

SECTION 13220

PRE-ENGINEERED PEDESTRIAN BRIDGE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Work shall include five (5) fully engineered clear span pedestrian bridges of galvanized steel construction with aluminum grating walking surface and horizontal safety railings. Span lengths and walking surface widths shall be as shown on the Contract Documents and/or specified herein. Pre-engineered pedestrian bridge manufacturer shall also provide a surface mounted safety railing system at the ends of bridge spans to match bridge safety railings as indicated on the contract drawings. The requirements or this specification shall be regarded as minimum standards for design and construction.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03300 — Cast-In-Place Concrete

B. Section 05010 — Metal Materials

C. Section 05035 — Galvanizing

D. Section 05300 — Metal Decking

E. Section 05830 — Bearing Devices and Anchorage

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of the Specifications, all work hereunder shall conform to the applicable requirements of the following documents to the extent that the requirements therein are not in conflict with the provisions of this Section.

1. AISC - American Institute of Steel Construction

2. Manual of Steel Construction: Allowable Stress Design

3. ANSI/AWS — American National Standards Institute / American Welding Society

4. CISC — Canadian Institute of Steel Construction

5. ANSI/AWS D1.1 Structural Welding Code

6. CISC Design Guide for Hollow Structural Section Connections

7. ACI — American Concrete Institute

8. ACI 318 — Building Code Requirements for Structural concrete

9. SSRC — Structural Stability Research Council

1.04 QUALIFIED MANUFACTURES

A. Manufactures/Fabricators must have at least five (5) years' experience designing and fabricating these type structures and a minimum of five (5) successful bridge projects, of similar construction, each of which has been in service at least three (3) years. List the location, bridge size, owner, and a contact for reference for each project.

B. Acceptable Manufactures/Fabricators shall be CONTECH Bridge Solutions Inc., Big R Bridge, Anderson Bridges or approved AISC certified equal.

1.05 SUBMITTALS

A. Shop drawings and diagrams shall be submitted to the engineer and owner for review after receipt of order. Submittal drawings shall be unique drawings, prepared to illustrate the specific portion of the work to be done. All relative design information such as member sizes, bridge reactions, design loads and general notes shall be clearly specified on the drawings. Drawings shall have cross referenced details and sheet numbers. All drawings shall be signed and sealed by a licensed Professional Engineer currently registered in the State of South Carolina.

B. Structural calculations for the bridge superstructure shall be submitted by the bridge manufacturer and reviewed by the engineer. All calculations shall be signed and sealed by a licensed Professional Engineer currently registered in the State of South Carolina. The calculations shall include all design information necessary to determine the structural adequacy of the bridge. The calculations shall include the following:

1. All AISC allowable stress checks for axial, bending and shear forces in the critical member of each truss member type (i.e. top chord, bottom chord, floor beam, vertical, etc.).

2. Checks for the critical connection failure modes for each truss member type (i.e. vertical, diagonal, floor beam, etc.). Special attention shall be given to all welded tube on tube connections.

3. All bolted splice connections.

4. Main truss deflection checks.

5. U-Frame stiffness checks (used to determine K factors for out-of-plane buckling of the top chord) for all half through or "pony" truss bridges.

6. Deck design.

NOTE: The analysis and design of triangulated truss bridges shall account for moments induced in members due to joint fixity where applicable. Moments due to both truss deflection and joint eccentricity must be considered.

C. Welder certifications in compliance with AWS standard qualification tests.

D. Welding procedures in compliance with Section 5.1.

1.06 WARRANTY

A. The bridge manufacturer shall warrant that it can convey good title to the goods, that they are free of liens and encumbrances and that their steel structure(s) are free of design, material and workmanship defects for a period of ten years from the date of delivery.

B. This warranty shall not cover defects in the bridge caused by abuse, misuse, overloading, accident, improper installation, maintenance, alteration or any other cause not expressly warranted. This warranty does not cover damage resulting from or relating to the use of any kind of de-icing material.

C. Repair, replacement or adjustment, at the sole discretion of the bridge manufacturer, shall be the exclusive remedy for defects under this warranty. Under no circumstances shall the bridge manufacturer be liable for any consequential or incidental damages.

D. Any claim under this warranty shall be made promptly and directly to the Bridge Manufacturer who shall have the option, to repair, replace or adjust any covered defect without charge to the original purchaser.

PART 2-- PRODUCTS

2.01 SPAN

A. Bridge span shall be as shown on the contract drawings and shall be as measured from each end of the bridge structure.

2.02 WIDTH

A. Bridge width shall be 4'-0" and shall be as measured from the inside face of structural elements at deck level.

2.03 BRIDGE SYSTEM TYPE

A. Bridge(s) shall be designed as a Pratt Style Truss that has one (1) diagonal per panel and plumb end vertical members. Interior vertical members may be either plumb or perpendicular to the chord faces.

B. Bridge(s) shall be designed utilizing an underhung floor beam (top of floor beam welded to the bottom of the bottom chord) or be designed utilizing an H-Section configuration where the floor beams are placed up inside the trusses and attached to the truss verticals.

C. The bridge manufacturer shall determine the distance from the top of the deck to the top and bottom truss members based upon structural and/or shipping requirements.

D. The top of the top chord shall not be less than 54 inches above the top of the finished walking surface elevation.

2.04 MEMBER COMPONENTS

A. All members of the vertical trusses (top and bottom chords, verticals, and diagonals) shall be fabricated from square and/or rectangular structural steel tubing. Other structural members and bracing shall be fabricated from structural steel shapes or square and rectangular structural steel tubing.

B. Unless the floor and fastenings are specifically designed to provide adequate lateral support to the top flange of open shape stringers (w-shapes or channels), a minimum of one stiffener shall be provided in each stringer at every floor beam location.

2.05 ATTACHMENTS

A. Safety Rails

1. Horizontal safety rails shall be placed on the structure up to a minimum height of 3′-6″ above the deck surface. Safety rails shall be placed so as to prevent a 4″ sphere from passing through the truss. Safety rails shall be placed on the inside of the structure. Safety rails placed on the inside of the truss shall have their ends sealed and ground smooth so as to produce no sharp edges.

2. The safety rail system shall be designed for the design loads required per the South Carolina Building Code.

B. Toe Plate

1. The bridge shall be supplied with a removable toe plate mounted to the inside face of both trusses. The toe plate shall be a minimum of 4 inches high. Toe plating will be attached to the truss members at a height adequate to provide a 2″ gap between the bottom of the plate and the top of the deck or the top of the bottom chord, whichever is higher. The span of unstiffened flat toe plating (from center to center of supports) shall not exceed 5′-8″.

2.06 CAMBER

A. The bridge shall have a vertical camber dimension at midspan equal to 100% of the full dead load deflection plus 1% of the full length of the bridge.

2.07 ELEVATION DIFFERENCE

A. The bridge supports shall be constructed at the same elevation on both ends of the bridge. Manufacturer shall coordinate bearing requirements with the Contractor prior to placement of concrete supports.

PART 3 -- EXECUTION

3.01 DESIGN

A. Structural design of the bridge structural system shall be performed by or under the direct supervision of a licensed professional engineer and done in accordance with recognized engineering practices and principles. The design Engineer of Record shall be a Professional Engineer currently registered in the State of South Carolina.

B. Design loads shall be in accordance with industry standards but shall not be less than required per applicable portions of the South Carolina Building Code.

C. The bridge structure design shall consider its own dead load which may include but is not limited to superstructure truss system, decking, concrete walking surface and safety railing.

D. Uniform Live Load

1. Main Members: Main supporting members, including girders, trusses and arches shall be designed for a pedestrian live load of 85 pounds per square foot of bridge walkway area. The pedestrian live load shall be applied to those areas of the walkway so as to produce maximum stress in the member being designed.

2. Secondary Members: Bridge decks and supporting floor systems, including secondary stringers, floor beams and their connections to main supporting members shall be designed for a live load of 85 pounds per square foot, with no reduction allowed.

E. Concentrated Loads

The bridge superstructure, floor system and decking shall be designed for a concentrated load of 1,000 pounds placed on any area 2.5 ft x 2.5 ft square.

F. Wind Load

1. Horizontal Forces

a) The bridges shall be designed for wind pressures based on a design wind speed of 155 mph as defined per ASCE 7-10 for a risk category III structure.

b) The wind load shall be applied horizontally at right angles to the longitudinal axis of the structure.
c) The wind loading shall be considered both in the design of the lateral load bracing system and in the design of the truss vertical members, floor beams and their connections.

2. Overturning Forces

The effect of forces tending to overturn structures shall be calculated assuming that the wind direction is at right angles to the longitudinal axis of the structure. In addition, an upward force shall be applied at the windward quarter point of the transverse superstructure width. This force shall be 20 pounds per square foot of deck.

3. Top Chord/Railing Loads

The top chord, truss verticals, and floor beams shall be designed for lateral wind loads (per Section 3.1.4.1) and for any loads required to provide top chord stability as outlined in Section 3.3.6; however, in no case shall the load be less than 50 pounds per lineal foot or a 200 pound point load, whichever produces greater stresses, applied in any direction at any point along the top chord or at the top of the safety system (42" or 54" above deck level), if higher than the top chord.

4. Load Combinations

The loads listed herein shall be combined and factored (if applicable) per the current edition of the South Carolina Building Code. Foundation reactions shall be provided in the submittal package for verification by the EOR of capacity of the supporting structure.

G. Deflection

1. The vertical deflection of the main trusses due to service pedestrian live load shall not exceed 1/400 of the span.

2. The vertical deflection of cantilever spans of the structure due to service pedestrian live load shall not exceed 1/300 of the cantilever arm length.

3. The deflection of the floor system members (floor beams and stringers) due to service pedestrian live load shall not exceed 1/360 of their respective spans.

4. The service pedestrian live load shall be 85 PSF, reduced in accordance with Section 3.1.2.1, but should in no case be less than 65 PSF for deflection checks.

5. The horizontal deflection of the structure due to lateral wind loads shall not exceed 1/500 of the span under the wind loads specified in Section 3.03C.

H. Minimum Thickness of Metal

1. The minimum thickness of all structural steel members shall be 3/16" nominal and be in accordance with the AISC Manual of Steel Constructions' "Standard Mill Practice Guidelines". For ASTM A500 and ASTM A847 tubing, the section properties used for design shall be per the Steel Tube Institute of North America's Hollow Structural Sections "Dimensions and Section Properties".

I. Welded Tubular Connections

1. When outside the “validity range” defined in these design guidelines, the following limit states or failure modes must be checked:

    a. Chord face plastification
    b. Punching shear (through main member face)
    c. Material failure
        i. Tension failure of the web member
        ii. Local buckling of a compression web member
    d. Weld failure
        i. Allowable stress based on “effective lengths”
        ii. “Ultimate” capacity
    e. Local buckling of a main member face
    f. Main member failure:
        i. Web or sidewall yielding
        ii. Web or sidewall crippling
        iii. Web or sidewall buckling
        iv. Overall shear failure

2. All tubular joints shall be plain unstiffened joints (made without the use of reinforcing plates) except as follows:

3. Floor beams hung beneath the lower chord of the structure may be constructed with or without stiffener (or gusset) plates, as required by design.

4. Floor beams which frame directly into the truss verticals (H-Section bridges) may be designed with or without end stiffening plates as required by design.

5. Where chords, end floor beams and in high profiles the top end struts weld to the end verticals, the end verticals (or connections) may require stiffening to transfer the forces from these members into the end vertical.

6. Truss vertical to chord connections.

    NOTE: The effects of fabrication tolerances shall be accounted for in the design of the structure. Special attention shall be given to the actual fit-up gap at welded truss joints.

J. Top Chord Stability

1. The top chord shall be considered as a column with elastic lateral supports at the panel points. The critical buckling force of the column, so determined, shall exceed the maximum force from dead load and live load (uniform or vehicular) in any panel of the top chord by not less than 50 percent for parallel chord truss bridges or 100 percent for bowstring bridges.

K. Bearing Devices

1. Bridge bearings shall be as specified in Section 05830 – Bearing Devices and Anchorage. One end of the bridge will be fixed by fully tightening the nuts on the anchor bolts at that end. The opposite end will have finger tight only nuts to allow movement under thermal expansion or contraction.

2. The bridge bearings support shall be as detailed on the Contract Drawings.

L. Support Bearings

1. The bridge manufacturer shall determine the number, diameter, embedment depth, minimum grade and finish of all anchor bolts. The anchor bolts shall be designed to resist all horizontal and uplift forces to be transferred by the superstructure to the supporting structures. Engineering design of the bridge supporting structures shall be the responsibility of the support structure engineer. The contractor shall provide all materials, including anchor bolts, for construction of the bridge supporting structures. The contractor shall install the anchor bolts in accordance with the manufacturer's anchor bolt spacing and embedment dimensions.

2. Information as to bridge support reactions and anchor bolt locations will be furnished by the bridge manufacturer after receipt of order and after the bridge design is complete.

3.02 WELDING TESTS

A. Welding and weld procedure qualification tests shall conform to the provisions of ANSI/AWS D1.1 “Structural Welding Code”, 1996 Edition. Filler metal shall be in accordance with the applicable AWS Filler Metal Specification (i.e. AWS A 5.28 for the GMAW Process). For exposed, bare, unpainted applications of corrosion resistant steels (i.e. ASTM A588 and A847), the filler metal shall be in accordance with AWS D1.1, Section 3.7.3.

3.03 WELDERS

A. Welders shall be properly accredited operators, each of whom shall submit certification of satisfactorily passing AWS standard qualification tests for all positions with unlimited thickness of base metal, have a minimum of 6 months experience in welding tubular structures and have demonstrated the ability to make uniform sound welds of the type required.

PART 4 -- MATERIALS

4.01 STEEL

A. Structural Steel shall be Galvanized

1. Bridges shall be galvanized and shall be fabricated using ASTM A500 grade C cold-formed welded square and rectangular tubing (Fy = 50,000 psi) and/or ASTM A36 (Fy = 36,000 psi) plate and structural steel shapes. Splice plates, if required, shall be ASTM A36. Steel members, fabrications and assemblies shall be Hot Dip Galvanized in accordance with ASTM A123, after fabrication is completed.

4.02 DECKING

A. Grate Decking

1. Aluminum Grating shall conform to the requirements of Specification Section 05531, Article 2.03.

PART 5 -- FABRICATION

5.01 GENERAL REQUIREMENTS

A. Drain Holes

1. When the collection of water inside a structural tube is a possibility, either during construction or during service, the tube shall be provided with a drain hole at its lowest point to let water out.

B. Welds

1. Special attention shall be given to developing sufficient weld throats on tubular members. Fillet weld details shall be in accordance with AWS D1.1, Section 3.9 (See AWS Figure 3.2). Unless determined otherwise by testing, the loss factor "Z" for heel welds shall be in accordance with AWS Table 2.8. Fillet welds which run onto the radius of a tube shall be built up to obtain the full throat thickness (See Figure 7.1). The maximum root openings of fillet welds shall not exceed 3/16" in conformance with AWS D1.1, Section 5.22. Weld size or effective throat dimensions shall be increased in accordance with this same section when applicable (i.e. fit-up gaps > 1/16").

The fabricator shall have verified that the throat thickness of partial joint penetration groove welds (primarily matched edge welds or the flare-bevel-groove welds on underhung floor beams) shall be obtainable with their fit-up and weld procedures. Matched edge welds shall be "flushed" out when required to obtain the full throat or branch member wall thickness.

For full penetration butt welds of tubular members, the backing material shall be fabricated prior to installation in the tube so as to be continuous around the full tube perimeter, including corners. Backing may be of four types:

- A "box" welded up from four (4) plates.
- Two "channel" sections, bent to fit the inside radius of the tube, welded together with full penetration welds.

- A smaller tube section which slides inside the spliced tube.
- A solid plate cut to fit the inside radius of the tube.

Corners of the “box” backing, made from four plates, shall be welded and ground to match the inside corner radii of the chords. The solid plate option shall require a weep hole either in the chord wall above the “high side” of the plate or in the plate itself. In all types of backing, the minimum fit-up tolerances for backing must be maintained at the corners of the tubes as well as across the “flats”.

C. Sealing and Caulking

1. To prevent rust runs on painted structures, open ends of all tubes shall be capped and seal welded. Wherever practical, member end connections and steel on steel contact surfaces, such as stringer to floor beam connections, shall be welded all around. Long seams between members or any seam which cannot be practically welded shall be caulked.

D. Paint Clearance

1. To provide adequate clearance for initial painting and future recoating, a minimum of a 1-1/2″ gap shall be provided between any two opposing painted surfaces. If this gap cannot be maintained, member sizes shall be increased, or filler plates added to bring the opposing surfaces in contact for seal welding.

5.02 QUALITY CERTIFICATION

A. Bridge(s) shall be fabricated by a fabricator who is currently certified by the American Institute of Steel Construction to have the personnel, organization, experience, capability, and commitment to produce fabricated structural steel for the category “Major Steel Bridges” as set forth in the AISC Certification Program with Fracture Critical Endorsement. Quality control shall be in accordance with procedures outlined for AISC certification. For painted structures, the fabricator must hold a "Sophisticated Paint Endorsement" as set forth in the AISC certification program. Furthermore, the bridge(s) shall be fabricated in a facility owned and/or leased by the corporate owner of the manufacturer, and fully dedicated to bridge manufacturing.

5.03 CLEANING AND SURFACE PREPARATION

A. Steel that is to be fabricated shall be cleaned by solvent or hand tools, or shot blasted, as needed to clean and remove rust and mill scale that might impede accuracy of fit-up or quality of fabrication prior to processing. Steel to be galvanized shall be prepared in accordance with the galvanizer’s recommendations.

5.04 APPLICATION OF COATING

A. Galvanize steel members, fabrications, and assemblies after fabrication by the hot dip process in accordance with ASTM A-123.

B. Safeguard products against steel embrittlement in conformance with ASTM A-143.

C. Handle all articles to be galvanized in such a manner as to avoid any mechanical damage and to minimize distortion.

PART 6 -- DELIVERY AND ERECTION

A. Delivery is made to a location nearest the site which is easily accessible to normal over-the-road tractor/trailer equipment. All trucks delivering bridge materials will need to be unloaded at the time of arrival.

B. The manufacturer will provide detailed, written instruction in the proper lifting procedures and splicing procedures (if required). The method and sequence of erection shall be the responsibility of others.

C. The bridge manufacturer shall provide written inspection and maintenance procedures to be followed by the bridge owner.

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SECTION 15000

BASIC MECHANICAL REQUIREMENTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install to the required line and grade, all piping together with all fittings and appurtenances, required for a complete installation. All piping located outside the face of structures or building foundations and all piping embedded in concrete within a structure or foundation shall be considered exterior piping.

B. The Contractor shall furnish and install fittings, couplings, connections, sleeves, adapters, harness rods and closure pieces as required to connect pipelines of dissimilar materials and/or sizes herein included under this Section and other concurrent Contracts for a complete installation.

C. The Contractor shall furnish all labor, materials, equipment, tools, and services required for the furnishing, installation and testing of all piping as shown on the Drawings, specified in this Section and required for the Work. Piping shall be furnished and installed of the material, sizes, classes, and at the locations shown on the Drawings and/or designated in this Section. Piping shall include all fittings, adapter pieces, couplings, closure pieces, harnessing rods, hardware, bolts, gaskets, wall sleeves, wall pipes, hangers, supports, and other associated appurtenances for required connections to equipment, valves, or structures for a complete installation.

D. Piping assemblies under 4-inch size shall be generally supported on walls and ceilings, unless otherwise shown on the Drawings or ordered by the Engineer, being kept clear of openings and positioned above "headroom" space. Where practical, such piping shall be run in neat clusters, plumb and level along walls, and parallel to overhead beams.

E. The Contractor shall provide taps on piping where required or shown on the Drawings. Where pipe or fitting wall thicknesses are insufficient to provide the required number of threads, a boss or pipe saddle shall be installed.

F. The work shall include, but not be limited to, the following:

1. Connections to existing pipelines.

2. Test excavations necessary to locate or verify existing pipe and appurtenances.

3. Installation of all new pipe and materials required for a complete installation.

4. Cleaning, testing and disinfecting as required.

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1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Division 1, General Requirements

B. Division 2, Sitework

C. Division 5, Metals

D. Division 9, Finishes

E. Division 11, Equipment

F. Division 16, Electrical

1.03 MATERIAL CERTIFICATION AND SHOP DRAWINGS

A. The Contractor shall furnish to the Owner (through the Engineer) a Material Certification stating that the pipe materials and specials furnished under this Section conform to all applicable provisions of the corresponding Specifications. Specifically, the Certification shall state compliance with the applicable standards (ASTM, AWWA, etc.) for fabrication and testing.

B. Shop Drawings for major piping (2-inches in diameter and greater) shall be prepared and submitted in accordance with Section 01300 – Submittals. In addition to the requirements of Section 01300 – Submittals, the Contractor shall submit laying schedules and detailed Drawings in plan and profile for all piping as specified and shown on the Drawings.

C. Shop Drawings shall include, but not be limited to, complete piping layout, pipe material, sizes, class, locations, necessary dimensions, elevations, supports, hanger details, pipe joints, and the details of fittings including methods of joint restraint. No fabrication or installation shall begin until Shop Drawings are approved by the Engineer.

PART 2 -- PRODUCTS

2.01 GENERAL

A. All specials and every length of pipe shall be marked with the manufacturer's name or trademark, size, class, and the date of manufacture. Special care in handling shall be exercised during delivery, distribution, and storage of pipe to avoid damage and unnecessary stresses. Damaged pipe will be rejected and shall be replaced at the Contractor's expense. Pipe and specials stored prior to use shall be stored in such a manner as to keep the interior free from dirt and foreign matter.

B. Testing of pipe before installation shall be as described in the corresponding ASTM or AWWA Specifications and in the applicable standard specifications listed in the following sections. Testing after the pipe is installed shall be as specified in Section 3.09.

C. Joints in piping shall be of the type as specified in the appropriate Piping System Schedule in Section 15390, Schedules.

D. ALL BURIED EXTERIOR PIPING SHALL HAVE RESTRAINED JOINTS FOR THRUST PROTECTION UNLESS OTHERWISE SPECIFIED OR SHOWN ON THE DRAWINGS. ALL EXPOSED EXTERIOR PIPING SHALL HAVE FLANGED JOINTS, UNLESS OTHERWISE SPECIFIED OR SHOWN ON THE DRAWINGS.

E. The Drawings indicate work affecting existing piping and appurtenances. The Contractor shall excavate test pits as required of all connections and crossings which may affect the Contractor's work prior to ordering pipe and fittings to determine sufficient information for ordering materials. The Contractor shall take whatever measurements that are required to complete the work as shown or specified.

2.02 SLEEVES

A. Unless shown otherwise, all piping passing through walls and floors shall be installed in sleeves or wall castings accurately located before concrete is poured, or placed in position during construction of masonry walls. Sleeves passing through floors shall extend from the bottom of the floor to a point 3 inches above the finished floor, unless shown otherwise. Water stop flanges are required on all sleeves located in floors or walls which are continually wet or under hydrostatic pressure on one or both sides of the floor or wall.

B. Sleeves shall be cast iron, black steel pipe, or fabricated steel in accordance with details shown on the Drawings. If not shown on the Drawings, the Contractor shall submit to the Engineer the details of sleeves he proposes to install; and no fabrication or installation thereof shall take place until the Engineer's approval is obtained. Steel sleeves shall be fabricated of structural steel plate in accordance with the standards and procedures of AISC and AWS. Steel sleeve surfaces shall receive a commercial sandblast cleaning and then be shop painted in accordance with Section 09900 – Painting.

C. When shown on the Drawings or otherwise required, the annular space between the installed piping and sleeve shall be completely sealed against a maximum hydrostatic pressure of 20 psig. Seals shall be mechanically interlocked, solid rubber links, trade name "Link-Seal", as manufactured by Garlock Pipeline Technologies (GPT) or equal. Rubber link, seal-type, size, and installation thereof, shall be in strict accordance with the manufacturer's recommendations. For non-fire rated walls and floors, pressure plate shall be glass reinforced nylon plastic with EPDM rubber seal and 304 stainless steel bolts and nuts. For fire rated walls and floors, two independent seals shall be provided consisting of low carbon steel, zinc galvanized pressure plates, silicon rubber seals and low carbon steel, zinc galvanized bolts and nuts.

D. Cast iron mechanical joint adapter sleeves shall be Clow # 1429, as manufactured by the Clow Corp., or equal. Mechanical joint adapter sleeves shall be provided with suitable gasket, follower ring, and bolts to effect a proper seal. In general, sleeves installed in walls, floors, or roofs against one side of which will develop a hydrostatic pressure, or through which leakage of liquid will occur, shall be so sealed. If welded waterstop flanges are employed, welds shall be 360 degree continuous on both sides of flange.

2.03 MECHANICAL COUPLINGS (SPLIT TYPE - GROOVED END)

A. Grooved end pipe couplings shall be furnished as specified or shown on the Drawings.

B. Materials shall be of malleable iron and couplings shall be rated for the same pressures as the connecting piping.

C. Gaskets shall be rubber. Bolts and nuts shall be heat treated carbon steel track bolts and shall be plated.

D. After installation, buried couplings shall receive two heavy coats of an approved coal tar which is compatible with the finish of the coupling. Exposed couplings shall be painted in accordance with Section 09900 - Painting.

E. Couplings shall be manufactured by Victaulic Company of America Style 31 or equal.

2.04 HEAT TRACED PIPING

A. Exposed pipes to be insulated shall also be protected from freezing by heat tracing. Freeze protection heat tracing shall consist of twin 16 AWG copper brass wires with a semiconductor polymer core where electrical resistance varies with temperature. The heat tracing shall have a fluoropolymer outer jacket for corrosion resistance. The heat tracing shall be rated for three (3) watts per foot output, self-regulating with a maximum temperature of 150°F, equal to a Chromalox No. SRL3-1CT383400. Maximum length for tape shall be 300 feet for each circuit. Temperature controller shall be provided to sense pipe temperature to determine on or off condition of the heat tracing. Temperature control shall be equal to a Chromalox No. RTBC-2-384729. The heat tracing system shall operate on 120 VAC. See Drawings for installation detail. Heat tracing of piping shall be provided as specified in Section 15390 – Schedules.

2.05 FLEXIBLE RESTRAINED EXPANSION JOINTS

A. Restrained expansion joints shall be manufactured of 60-42-10 ductile iron conforming to material and other applicable requirements of ANSI/AWWA C153/A21.53.

B. Each pressure containing component shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the materials requirements of, and tested in accordance with, ANSI/AWWA C213 and shall meet or exceed the requirements of ANSI/AWWA C550.

C. Seals shall conform to the applicable requirements of ANSI/AWWA C111/A21.11.

D. All bolts used in the assemblies shall be stainless steel and shall be coated with a premium quality epoxy.

E. Flanged ends shall comply with ANSI/AWWA C110/A21.10, with the addition of O-ring groove and O-ring.

F. Mechanical joint ends shall comply with ANSI/AWWA C153/A21.53.

G. Restrained expansion joints shall have a minimum pressure rating of 350 psi with a minimum safety factor of 3:1. Each assembly shall be tested at 350 psi before shipment.

H. Restrained expansion joints shall provide for self restraint without tie rods and shall provide for expansion and contraction capabilities cast as an integral part of the end connection.

I. Flexible restrained expansion joints shall allow for 8-inches (+6"-2") minimum expansion.

J. Flexible restrained expansion joints shall consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint having a minimum of 15° deflection per ball.

K. Restrained expansion joints shall be the Single Ball or Double Ball FLEX-TEND Expansion Joint as manufactured by EBAA Iron Inc., or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All piping shall be installed by skilled workmen and in accordance with the best standard practice for piping installation as shown on the Drawings, specified or recommended by the pipe manufacturer. Proper tools and appliances for the safe and convenient handling and installing of the pipe and fittings shall be used. Great care shall be taken to prevent any pipe coating from being damaged on the inside or outside of the pipe and fittings. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be cracked, damaged, or otherwise defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced with a sound one in a satisfactory manner by the Contractor and at his own expense. Pipe and fittings shall be thoroughly cleaned before they are installed and shall be kept clean until they are accepted in the complete work. All piping connections to equipment shall be provided with unions or coupling flanges located so that piping may be readily dismantled from the equipment. At certain applications, Dresser, Victaulic, or equal, couplings may also be used. All piping shall be installed in such a manner that it will be free to expand and contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Unless otherwise shown or approved, provided a minimum headroom clearance under all piping of 7 feet 6 inches.

B. Unless otherwise shown or specified, all waste and vent piping shall pitch uniformly at a 1/4-inch per foot grade and accessible cleanouts shall be furnished and installed as shown and as required by local building codes. Installed length of waste and vent piping shall be determined from field measurements in lieu of the Drawings.

C. All excavation shall be made in such a manner and to such widths as will provide ample room for properly installing the pipe and permit thorough compaction of backfill around the pipe. The minimum trench widths shall be in strict accordance with the "Trench Width Excavation Limits" as shown on the Drawings. All excavation and trenching shall be done in strict accordance with these specifications and all applicable parts of the OSHA Regulations, 29CFR 1926, Subpart P.

D. ALL EXCAVATION REQUIRED BY THIS CONTRACT SHALL BE UNCLASSIFIED. NO ADDITIONAL PAYMENT WILL BE MADE FOR ROCK EXCAVATION REQUIRED FOR THE INSTALLATION OF PIPE OR STRUCTURES SHOWN ON THE DRAWINGS.

E. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.

F. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, or obstructions.

G. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet. The Contractor shall excavate the trenches to the full depth, width and grade indicated on the Drawings including the relevant requirements for bedding. The trench bottoms shall then be examined by the Engineer as to the condition and bearing value before any pipe is laid or bedding is placed.

H. No pressure testing shall be performed until the pipe has been properly backfilled in place. All pipe passing through walls and/or floors shall be provided with wall pipes or sleeves in accordance with the specifications and the details shown on the Drawings. All wall pipes shall be of ductile iron and shall have a water stop located in the center of the wall. Each wall pipe shall be of the same class, thickness, and interior coating as the piping to which it is joined. All buried wall pipes shall have a coal tar outside coating on exposed surfaces.

I. JOINT DEFLECTION SHALL NOT EXCEED 75 PERCENT OF THE MANUFACTURERS RECOMMENDED DEFLECTION. Excavation and backfilling shall conform to the requirements of Section 02200 - Earthwork, and as specified herein. Maximum trench widths shall conform to the Trench Width Excavation Limits shown on the Drawings. All exposed, submerged, and buried piping shall be adequately supported and braced by means of hangers, concrete piers, pipe supports, or otherwise as may be required by the location.

J. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. UNDER NO CIRCUMSTANCES SHALL ANY OF THE MATERIALS BE DROPPED OR DUMPED INTO THE TRENCH.

K. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fitting, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.

L. All piping shall be installed in such a manner that it will be free to expand and/or contract without injury to itself or to structures and equipment to which it is connected. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade and shall be supported and braced against movement, temporary, or permanent. All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship. Pipes crossing within a vertical distance of less than or equal to one (1) foot shall be encased and supported with concrete at the point of crossing to prevent damage to the adjacent pipes as shown on the Drawings.

M. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation; and no pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at his own expense. Pipe shall not be laid in water or when trench conditions are unsuitable for work.

N. Proper and suitable tools and appliances for the safe convenient handling and laying of pipe shall be used and shall in general agree with manufacturer's recommendations.

O. AT THE CLOSE OF EACH WORK DAY THE END OF THE PIPELINE SHALL BE TIGHTLY SEALED WITH A CAP OR PLUG SO THAT NO WATER, DIRT, OR OTHER FOREIGN SUBSTANCE MAY ENTER THE PIPELINE, AND THIS PLUG SHALL BE KEPT IN PLACE UNTIL PIPE LAYING IS RESUMED.

P. During the laying of pipe, each pipe manufacturer shall provide his own supervisor to instruct the Contractor's pipe laying personnel in the correct procedure to be followed.

Q. Ordinarily only full lengths of pipe (as furnished by the pipe manufacturer) shall be used exceptions: closure pieces at manholes and areas where joint deflection is required.

R. For gravity sewer installations, the Contractor shall use a laser device to maintain the trench and pipe alignment. The laser device shall be re-checked for correct elevation and pipe alignment prior to pipe installation if the device is left in the pipe overnight. Corrected invert elevations at each manhole and any adjustments will be coordinated and approved by the Engineer.

S. ALL PIPING SHALL HAVE TYPE "A" BEDDING AS SHOWN ON THE DRAWINGS, UNLESS OTHERWISE SPECIFIED HEREIN OR INDICATED ON THE DRAWINGS.

T. Detector tape shall be installed 12 inches below final grade and directly above all buried potable water piping. The tape shall be blue and silver and shall be clearly and permanently labeled "Water". Detector tape shall be Lineguard III as manufactured by Lineguard, Inc., or equal.

U. AT THE CLOSE OF WORK EACH DAY PIPELINE TRENCHES SHALL BE COMPLETELY BACKFILLED. IN PAVED AREAS THE SURFACE SHALL BE RESTORED AS SPECIFIED IN SECTION 02510, PAVING AND SURFACING, TO ALLOW FOR TRAFFIC OVER THE TRENCH DURING NON-WORKING HOURS. UNDER NO CONDITIONS SHALL ANY PIPELINE TRENCH BE LEFT OPEN DURING NON-WORKING HOURS.

NOTE: STANDARD BEDDING CONDITION IS SPECIFIED ABOVE - ADD ANY SPECIAL BEDDING CONDITIONS HERE. VERIFY THAT PROPER DETAILS APPEAR ON DRAWINGS.

3.02 DUCTILE IRON PIPE

A. Ductile iron pipe (DIP) shall be installed in accordance with the requirements of the Ductile Iron Pipe Handbook published by the Ductile Iron Pipe Research Association, and AWWA C600.

B. Where it is necessary to cut ductile iron pipe in the field, such cuts shall be made carefully in a neat workmanlike manner using approved methods to produce a clean square cut. The outside of the cut end shall be conditioned for use by filing or grinding a small taper, at an angle of approximately 30 degrees.

C. UNLESS OTHERWISE APPROVED BY THE ENGINEER, FIELD WELDING OF DUCTILE IRON WILL NOT BE PERMITTED.

3.03 CARBON AND STAINLESS STEEL PIPE

A. Installation of steel pipe shall be by skilled workmen and shall conform to the applicable sections of AWWA Manual M-11. Joints for steel piping shall be either screwed, welded, or flanged as shown on the Drawings or as specified.

B. Welding in the field shall be performed only when requested on the shop drawings and permitted by the Engineer for carbon steel pipe. No welding of stainless steel pipe shall be allowed in the field. All field welds shall be radiographically inspected.

C. Installation of the steel casing pipe shall be by skilled workmen and in accordance with the best standard practice for steel pipe installation. Joints for steel casing pipe shall be butt welded.

1. The boring equipment to be used for installing the jacked casing shall be of such size and capacity to allow the boring to proceed in a safe and expeditious manner. The installation of the casing and boring of the hole shall be done simultaneously to avoid cave-ins or settlement and for safety of traffic above.

2. The Contractor shall check the vertical and horizontal alignment of the casing by survey instrument at least once during each four feet of advance, or as directed by the Engineer. Pits shall be well sheeted and braced as necessary for safe and adequate access for workmen, inspectors and materials and shall be of a size suitable to equipment and material handling requirements.

3. Under no conditions shall jetting or wet boring of encasement under pavement be allowed.

4. After installation of the carrier pipe, each end of the casing pipe shall be made watertight with a brick masonry bulkhead. In addition, a Class B concrete cradle shall be provided from each end of the bulkhead to the first pipe joint outside of the bulkhead.

3.04 JOINTS IN PIPING

A. Restrained joints shall be provided on all pipe joints as specified herein and shown on the Drawings. Restrained joints shall be made up similar to that for push-on joints.

B. Push-on joints include a single rubber gasket which fits into the bell end of the pipe. The gasket shall be wiped clean, flexed and then placed in the socket. Any bulges in the gasket which might interfere with the entry of the plain end of the pipe shall be removed. A thin film of lubricant shall be applied to the gasket surface which will come into contact with the spigot end of the pipe. The lubricant shall be furnished by the pipe manufacturer. The plain end of the pipe, which is tapered for ease of assembly, shall be wiped clean and a thick film of lubricant applied to the outside. The pipe shall be aligned and carefully entered into the socket until it just makes contact with the gasket. The joint assembly shall be completed by entering the pipe past the gasket until it makes contact with the bottom of the socket. The pipe shall be pulled "home" with an approved jack assembly as recommended by the pipe manufacturer. If assembly is not accomplished by reasonable force, the plain end shall be removed, and the condition corrected.

C. Flanged joints shall be brought to exact alignment and all gaskets and bolts or studs inserted in their proper places. Bolts or studs shall be uniformly tightened around the joints. Where stud bolts are used, the bolts shall be uniformly centered in the connections and equal pressure applied to each nut on the stud. Pipes in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot.

D. Mechanical joints shall be made up with gaskets, glands and bolts. When a joint is to be made up, the bell or socket and plain end shall be cleaned and washed with a solution of mild soap in water; the gland and gasket shall be slid onto the plain end and the end then entered into the socket until it is fully "home" on the centering ring. The gasket shall then be painted with soapy water and slid into position, followed by the gland. All bolts shall be inserted and made up hand tight and then tightened alternately to bring the gland into position evenly. Excessive tightening of the bolts shall be avoided. All nuts shall be pulled up using a torque wrench which will not permit unequal stresses in the bolts. Torque shall not exceed the recommendations of the manufacturer of the pipe and bolts for the various sizes. Care shall be taken to assure that the pipe remains fully "home" while the joint is being made. Joints shall conform to the applicable AWWA Specifications.

E. Threaded and/or screwed joints shall have long tapered full depth threads to be made with the appropriate paste or jointing compound, depending on the type of fluid to be processed through the pipe. All pipe up to, and including 1-1/2-inches, shall be reamed to remove burr and stood on end and well pounded to remove scale and dirt. Wrenches on valves and fittings shall be applied directly over the joint being tightened. Not more than three pipe threads shall be exposed at each connection. Pipe, in all lines subject to temperature changes shall be cut short and cold sprung into place to compensate for expansion when hot. Joints in all piping used for chlorine gas lines shall be made up with a glycerine and litharge cement. Joints in plastic piping (PVC/CPVC) shall be laid and joints made with compounds recommended by the manufacturer. Installation shall conform to the requirements of ASTM D2774 and ASTM D2855. Unions required adjacent to valves and equipment.

F. Soldered joints shall have the burrs removed and both the outside of pipe and the inside of fittings shall be thoroughly cleaned by proper tools recommended for that purpose. Flux shall be applied to both pipe and inside of fittings and the pipe placed into fittings and rotated to insure equal distribution of flux. Joints shall be heated and solder applied until it shows uniformly around the end of joints between fitting and pipe. All joints shall be allowed to self-cool to prevent the chilling of solder. Combination flux and solder paste manufactured by a reputable manufacturer is acceptable. Unions required adjacent to valves and equipment.

G. Welded joints shall be made by competent operators in a first class workmanlike manner, in complete accordance with ANSI B31.1 and AWWA C206. Welding electrodes shall conform to ASTM A233, and welding rod shall conform to ASTM A251. Only skilled welders capable of meeting the qualification tests for the type of welding which they are performing shall be employed. Tests, if so required, shall be made at the expense of the Contractor, if so ordered by the Engineer. Unions shall be required adjacent to valves and equipment.

H. Copper joints shall be thoroughly cleaned and the end of pipes uniformly flared by a suitable tool to the bevels of the fittings used. Wrenches shall be applied to the bodies of fittings where the joint is being made and in no case to a joint previously made. Dimensions of tubing and copper piping shall be in complete accordance with the fittings used. No flare joints shall be made on piping not suited for flare joints. Installations for propane gas shall be in accordance with NFPA 54 and/or 58.

I. Solvent or adhesive welded joints in plastic piping shall be accomplished in strict accordance with the pipe manufacturer's recommendations, including necessary field cuttings, sanding of pipe ends, joint support during setting period, etc. Care shall be taken that no droppings or deposits of adhesive or material remain inside the assembled piping. Solvent or adhesive material shall be compatible with the pipe itself, being a product approved by the pipe manufacturer. Unions are required adjacent to valves and equipment. Sleeve-type expansion joints shall be supplied in exposed piping to permit 1-inch minimum of expansion per 100 feet of pipe length.

J. Dielectric isolation such as flange isolation kits, dielectric unions, or similar, shall be installed wherever dissimilar metals are connected according to the following table.

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Ductile Iron	Mild Steel/ Carbon Steel	Copper	Brass	Stainless Steel
Zinc			●	●	●	●	●	●	●
Galvanized Steel			●	●	●	●	●	●	●
Aluminum	●	●		●	●	●	●	●	●
Cast Iron	●	●	●				●	●	●
Ductile Iron	●	●	●				●	●	●
Mild Steel/ Carbon Steel	●	●	●				●	●	●
Copper	●	●	●	●	●	●			●
Brass	●	●	●	●	●	●			●
Stainless Steel	●	●	●	●	●	●	●	●	

1. "●" signifies dielectric isolation is required between the two materials noted.
2. Consult Engineer for items not listed in table.
3. Provide flange isolation kits for all flanged connections of dissimilar metals and hardware including connections to equipment.
4. Contractor shall include all isolation descriptions with piping submittals.

K. Eccentric reducers shall be installed where air or water pockets would otherwise occur in mains because of a reduction in pipe size.

L. Joints in polypropylene and polyvinylidelene fluoride pipe shall be butt fusion weld. All butt welding shall follow the requirements of ASTM D-2657 and the manufacturer's recommendations.

3.05 FLUSHING AND TESTING

A. All piping shall be properly flushed and tested unless specifically exempted elsewhere in the Specifications or otherwise approved by the Engineer. Air and gas pipelines shall be flushed and tested with compressed air. Gravity sewer piping shall be flushed and tested as specified in Section 02604 - Utility Structures. All other liquid conveying pipelines shall be flushed and tested with water. The Contractor shall furnish and install all means and apparatus necessary for getting the air or water into the pipeline for flushing and testing including pumps, compressors, gauges, and meters, any necessary plugs and caps, and any required blow-off piping and fittings, etc., complete with any necessary reaction blocking to prevent pipe movement during the flushing and testing. All pipelines shall be flushed and tested in such lengths or sections as agreed upon among the Owner, Engineer, and Contractor. Test pressures shall be as specified in Section 15390 – Schedules, and shall be

measured at the lowest point of the pipe segment being tested. The Contractor shall give the Owner and Engineer reasonable notice of the time when he intends to test portions of the pipelines. The Engineer reserves the right, within reason, to request flushing and testing of any section or portion of a pipeline.

B. The Contractor shall provide water for all flushing and testing of liquid conveying pipelines. Raw water or non-potable water may be used for flushing and testing liquid pipelines not connected to the potable water system. Only potable water shall be used for flushing and testing the potable water system.

C. Air and gas piping shall be completely and thoroughly cleaned of all foreign matter, scale, and dirt prior to start-up of the air or gas system.

D. At the conclusion of the installation work, the Contractor shall thoroughly clean all new liquid conveying pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, etc., which may have entered the pipe during the construction period. If after this cleaning any obstructions remain, they shall be corrected by the Contractor, at his own expense, to the satisfaction of the Engineer. Liquid conveying pipelines shall be flushed at the rate of at least 2.5 feet per second for a duration suitable to the Engineer or shall be flushed by other methods approved by the Engineer.

E. Compressed/service air and gas piping shall be flushed by removing end caps from the distribution lines and operating one (1) compressor, in accordance with the manufacturer's instructions.

F. After flushing, all air piping shall be pressure and leak tested prior to coating and wrapping of welded joints. Immediately upon successful completion of the pressure and leak test, welded joints shall be thoroughly cleaned of all foreign matter, scale, rust, and discoloration and coated in accordance with the Specifications.

G. All process air piping shall be leak tested by applying a soap solution to each joint. Leak tests shall be conducted with one (1) blower in service at normal operating pressure.

H. During testing the piping shall show no leakage. Any leaks or defective piping disclosed by the leakage test shall be repaired or replaced by the Contractor, at his own expense, and the test repeated until all such piping shows tight.

I. All buried process air piping shall be pressurized to 25 psig and tested for leaks by applying a soap solution to each joint. The air supply shall be stopped and the pipe pressure monitored. System pressure shall not fall by more than 0.5% of the 25 psig test pressure over a one-hour test period. Should the system fail to hold the required pressure for one hour, the cause shall be determined and corrected and the test repeated until a successful test of the entire system is obtained.

J. Field leakage tests shall be performed for all submerged process air piping. The procedure shall consist of operating the system under clear nonpotable water for visual identification of all leaks. All field leakage tests shall be witnessed by the Engineer. All submerged piping shall be installed free of any leaks.

K. After flushing, all liquid conveying pipelines shall be hydrostatically tested at the test pressure specified in the appropriate Piping System Schedule in Section 15390 – Schedules. The procedure used for the hydrostatic test shall be in accordance with the requirements of AWWA C600. Each pipeline shall be filled with water for a period of no less than 24 hours and then subjected to the specified test pressure for 2 hours. During this test, exposed piping shall show no leakage. Allowable leakage in buried piping shall be in accordance with AWWA C600.

L. Any leaks or defective pipe disclosed by the hydrostatic test shall be repaired or replaced by the Contractor, at his own expense, and the test repeated until all such piping shows tight.

M. After flushing, all gas piping shall be leak tested in accordance with all local codes and regulations and in conformance with the recommendations or requirements of any National Institute or Association for the specific service application.

3.06 DISINFECTION

A. All pipe and fitting connected to and forming a part of a potable water supply shall be disinfected in accordance with the procedures described in AWWA C 651. Disinfection shall also be in accordance with the requirements of the South Carolina Department of Health and Environmental Control (SC DHEC) and the Owner.

B. Disinfection shall be accomplished after the pipe has been flushed, if applicable, and passed the hydrostatic test. Such piping shall be filled with 50 parts per million (PPM) of chlorine and held in contact for not less than 24 hours. Final tests after 24 hours contact time shall show a minimum residual chlorine content of 10 ppm in all parts of the system. Disinfection shall be repeated as often as necessary, and as directed by the Engineer and/or SCDHEC and/or the Owner until the minimum residual chlorine content of 10 ppm has been reached. The Contractor shall obtain certificates of satisfactory bacteriological tests and furnish them to the Owner before the request is made for acceptance of the work. The Contractor shall furnish and install, at his own expense, all means and apparatus necessary for performing the disinfection. The chlorine solution shall be thoroughly flushed out prior to placing the new sections of pipe in service. The Contractor is cautioned that the spent chlorine solution must be disposed of in such a way as not to be detrimental to animal, plant, or fish life. Chlorine residual tests will be made after flushing to assure that residual is not in excess of 1 ppm at any point in system.

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SECTION 15006

DUCTILE IRON PIPE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. All ductile iron pipe and specials shall be marked with the manufacturer's name or trademark, size, weight, thickness class, the date of manufacture, and the word "Ductile".

B. Ductile iron pipe (DIP) of the sizes shown or specified shall conform to ANSI A21.51 (AWWA C151), Grade 60-42-10 for ductile iron pipe centrifugally cast in metal molds or sand-lined molds. All ductile iron pipe shall conform to ANSI A21.50 (AWWA C150) for thickness design and shall be supplied in 18 or 20 foot nominal lengths or as required to meet the requirements of the Drawings. Fittings and specials shall be cast iron or ductile iron, conforming to the requirements of ANSI A21.10 (AWWA C110) or ANSI A21.53 (AWWA C153).

C. Minimum Class 53 pipe shall be used for flanged spools.

D. Reference Section 15000, Basic Mechanical Requirements

E. Reference Section 15390, Schedules, for pressure rating requirements for specific applications.

PART 2 -- PRODUCT

2.01 DUCTILE IRON PIPE AND FITTINGS

A. All pipe and fittings, with the exception of glass lined pipe and sleeves, shall be cement mortar lined. Linings shall conform to American Standard Specifications for Cement Mortar Lining for Cast Iron Pipe and Ductile Iron Pipe and Fittings, ANSI A21.4 (AWWA C104) and shall be standard thickness. The mortar lining shall be protected with the bituminous seal coat. All buried DIP and fittings shall have a bituminous coating on the exterior surfaces in accordance with ANSI A21.51 (AWWA C151). All exposed DIP and fittings shall have a shop applied prime coat in accordance with Section 09900 - Painting.

B. Glass-lined ductile iron pipe shall be furnished and installed where specified in the Exterior Piping System Schedule. The finished lining shall be from 0.008-inch to 0.012-inch thick, hardness of from 5 to 6 on the Mohs Scale, density of from 2.5 to 3.0 grams per cubic centimeter as measured in accordance with the requirements of ASTM D792 and be capable of withstanding a thermal shock of 350NF without crazing, blistering, or spalling. The lining shall be Ervite Type SG-14, as manufactured by the Ervite Corporation, Erie, Pa., Ferrock MEH-32, by Water Works Supply & Mfg., Co., Marysville, CA, or equal.

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C. Cutting of glass-lined pipe in the field shall be limited to only one piece per run of pipe, and this shall be for closure purposes only. Spalling of the glass liner shall be no more than 1/8-inch back from the cut. Flanges and bolt holes on spool pieces shall be aligned prior to glassing and shall be sealed and tested prior to shipment in accordance with the manufacturer's recommendation. Warping of flanges and/or pipe may be cause for rejection as determined by the Engineer.

D. Requirements for various types of joints are described in the following paragraphs. UNLESS OTHERWISE NOTED HEREIN OR ON THE DRAWINGS, ALL EXPOSED DUCTILE IRON PIPING SHALL HAVE FLANGED JOINTS.

E. Flanged joints and fittings shall have a minimum pressure rating of 250 psi with 125 lb. American Standard flanges. All flanges and fittings shall conform to the requirements of ANSI B16.1. Flanges shall be ductile iron and shall be of the threaded or screw on type. The face of the flanges shall be machined after installation of the flange to the pipe. No raised surface shall be allowed on flanges. Flanged pipe shall conform to the requirements of ANSI Specification A21.15, (AWWA C115). Pipe lengths shall be fabricated to meet the requirements of the Drawings.

F. Gaskets shall be the "Ring Gasket" type, 1/8-inch minimum thickness, cloth inserted rubber, red rubber or neoprene and shall be suitable for the service intended. Gaskets for glass lined pipe shall be TORUSEAL flange gasket, or equal. Bolts shall be of the size and length called for and in accordance with the "American Standard" and comply with the requirements of the ANSI/AWWA Standards. The bolts for flanged joints shall be a minimum ASTM A307; Grade B carbon steel and be in accordance with ANSI A21.10, (AWWA C110). The bolts shall have hexagonal heads and nuts, no washers shall be used.

G. Bell and spigot pipe shall be provided with push on, O-ring rubber gasket, compression type joints and shall conform to the requirements of ANSI A21.11 (AWWA C111). Fittings and specials shall be supplied with mechanical joints as specified for mechanical joint pipe. If required by installation conditions, pipe shall have cast-on lugs for adequately tying it together.

H. Mechanical joints and fittings shall conform to the requirements of ANSI A21.11, (AWWA C111). Joints shall be made employing a tapered rubber gasket forced into a tapered groove with a ductile iron follower ring. If required by installation conditions, pipe and fittings shall have cast-on lugs for adequately tying the pipe and fittings together. These shall be in conformance with standard practice and as outlined under the appropriate AWWA Specifications.

I. Bolts for mechanical joints shall be high strength corrosion resistant low-alloy steel tee-head bolts with hexagonal nuts.

J. Mechanical coupling joint pipe and fittings shall be split type, shouldered end. Coupling materials shall be malleable iron. Couplings shall have a minimum pressure rating and service equal to that of the connected piping. Gaskets shall be of rubber. Bolts and nuts shall be heat treated carbon steel track bolts and shall be plated. After installation, buried couplings shall receive two heavy coats of coal tar epoxy (min. 24 mil thickness) which is compatible with the finish of the couplings. Couplings shall be as manufactured by Victaulic Company of America Style 31, or equal.

K. Restrained joint pipe shall consist of factory manufactured bolted retainer rings, ductile iron locking segments held in place by rubber retainers, or ductile iron retaining rings that lock over the bell of the joint and are secured to prevent rotation, and factory welded retainer beads or rings on the spigot of the pipe. All components of the bolted or snap ring assemblies shall be constructed of corrosion-resistant, high strength, low-alloy steel. Restrained joint pipe shall be Flex-Ring or Lock-Ring type joints as manufactured by American Cast Iron Pipe Company, HP LOK or TR Flex as manufactured by US Pipe, Bolt-Lok or Snap-Lok as manufactured by Griffin Pipe Products, TR Flex or Super Lock as manufactured by Clow Water Systems Co., or approved equal.

L. Restrained fittings for piping systems 16-inches in diameter and greater shall have factory restraint systems identical to the factory restrained joint pipe specified in Item K above. All fittings shall be minimum pressure Class 250 unless otherwise specified.

M. Restrained fittings for pipe systems 14-inches in diameter and smaller shall be Mechanical Joint fittings with restraint assemblies such as Stargrip by Star Pipe Systems, Mega Lug by EBAA Iron, ONE LOK by Sigma, Grip Ring by Romac, or approved equal. Where threaded-rods are allowed, the rods and tabs shall be designed for the specified restraint system design pressure, shall have lengths less than 10 feet between fittings, and shall be painted with two heavy coats of coal tar epoxy after installation.

N. The manufactured systems for thrust restraint indicated above shall be used where restrained joint ductile iron pipe and fittings are specified or indicated on the drawings. Gripping gaskets are not an acceptable form of restraint. Thrust restraint and harnessing systems such as threaded-rods, friction clamps, retainer glands shall be used only where specifically specified herein, indicated on the drawings or if allowed by the Engineer in isolated applications where conditions warrant and necessitate their use. Concrete thrust blocks may be used in accordance with the schedule indicated on the drawings, if applicable.

O. Cast Iron Soil Pipe shall conform to the standards of the Cast Iron Soil Pipe Institute (CISPI) Specification HS-67, and also ANSI Specification A-112.5.2 for Hub & Spigot pipe or A.112.5.1 for Hub & Spigot pipe or A.112.5.1 for No-Hub Pipe. Pipe class shall be "Extra Heavy: (XH).

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SECTION 15013

STEEL PIPE FOR LOW PRESSURE PROCESS AIR SERVICE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. This specification shall apply to stainless-steel pipe for low pressure air service (less than 25 psig).

B. The AWWA Specifications referenced in this section are supplemented as follows:

1. An affidavit of compliance is required from the pipe manufacturer.

2. The steel manufacturer's certification that the material meets the ASTM Specification will be accepted in lieu of tests on specimens taken from the fabricated pipe.

3. The fabricator may purchase steel plates on the chemical basis only and shall furnish to the Owner certified test reports.

C. All parts of the materials furnished shall be amply designed, manufactured, and constructed for the maximum stresses occurring during fabrication, erection and operation. All materials shall be new and both workmanship and materials shall be of the very best quality, shall be entirely suitable for the service to which they will be subjected, and shall conform to all applicable sections of these Specifications. Manufacturer's designs shall accommodate all of the requirements of these Specifications.

D. The Contractor shall be responsible for the structural design of the stainless steel pipe, fittings, and couplings. The Contractor shall submit certification that the stainless steel pipe, fittings, and couplings have been designed to resist all loads implied and reasonably anticipated.

E. Reference Section 15000 – Basic Mechanical Requirements.

PART 2 -- PRODUCTS

2.01 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless steel pipe for process aeration and other low pressure air service for nominal pipe sizes ranging from three (3) inches to sixty (60) inches shall be manufactured from 304L stainless steel annealed and pickled sheets and plates per ASTM A240.

B. Stainless steel pipe shall be fabricated in accordance with ASTM A778 and shall be rated for at least 25 psig and 300 degrees Fahrenheit (°F). Only seamless or one (1) longitudinal seam shall be permitted unless otherwise required for fabrication of large diameter pipe in accordance with ASTM A774. Only stainless steel pipe shall be provided; tubing shall not be allowed. Stainless steel pipe shall be as manufactured by Douglas Brothers, Felker Bros. Corp., or Engineer approved equal.

C. Stainless steel pipe shall be manufactured to the nominal pipe sizes as listed in ANSI B36.19, Table 2, and shall have the following minimum wall thicknesses **unless otherwise specified elsewhere or shown on the Drawings**:

Nominal Pipe Size (inches)	Schedule/Gauge/Plate
4 and less	Schedule 5S (0.083-inch)
5 to 8	Schedule 5S (0.109-inch)
10 to 12	12 gauge (0.109-inch)
14 to 18	11 gauge (0.125-inch)
20	10 gauge (0.140-inch)
24 to 36	0.187-inch
42 to 48	0.250-inch
54 to 60	0.312-inch

D. Fittings shall be fabricated from the pipe specified and shall conform to ASTM A774, unless otherwise shown on the Drawings or required for proper installation.

E. Flanges where shown on the Drawings shall be a lap joint flange assembly consisting of a 304L stainless steel slip-on rolled angle ring with a 304L stainless steel drilled backup flange conforming to ASTM A240, and shall conform dimensionally to ANSI B16.1, Class 125. The leg of the angle ring shall not interfere with the flange bolt holes. Alternately, slip-on plate flanges conforming to ANSI B16.1, Class 125 are acceptable at specific locations as approved by the Engineer. The plate flange shall be continuously welded to the pipe. The backup flanges and plate flanges shall be supplied with the following nominal thicknesses:

Nominal Pipe Size (inches)	Flange Thickness (inches)
2-1/2 to 3	1/2
4	9/16
6 to 10	5/8
12 to 16	3/4
18 to 20	7/8
24 to 30	1
36	1-1/8
42	1-1/4
48	1-3/8
54	1-3/8
60	1-1/2

F. Bolts for flanged joints shall be of the size and length called for and in accordance with the "American Standard" and comply with the requirements of the ANSI/AWWA Standards. Bolts shall be per ANSI B18.2, stainless steel, type and grade to prevent galling. Bolts shall have hexagonal heads and nuts; no washers shall be used. Bolts used at all transitions to material other than stainless steel shall be furnished with dielectric insulation material service rated for 300 degrees Fahrenheit continuous service at 25 psig.

G. Gaskets for flanged joints shall be Viton or silicone material, “Ring-Gasket” type, 1/8-inch minimum thickness, and suitable for 300 degrees Fahrenheit continuous service at 25 psig. Dielectric gaskets shall be used at all transitions to material other than stainless steel. Segmented gaskets will not be acceptable.

H. Joints in piping 3 inches in diameter or larger shall be butt welded or flanged, unless otherwise shown on the Drawings. Joints in piping less than 3 inches in diameter shall be threaded, unless otherwise shown on the Drawings.

I. Welding practices for joints shall conform to those specified for the manufacture of the pipe and fittings in ASTM A774 and A778, and the specifications contained herein. All welds shall be free from burrs, snags, or rough projections.

J. Welding shall be performed by AWS-certified welders in conformance with standard procedures. Piping with wall thickness up to 11 gauge (0.125-inch) shall be welded with the TIG (GTAW) process. Heavier walls shall be properly beveled and have a root pass with the TIG (GTAW) process followed by subsequent passes with the TIG (GTAW), MIG (GMAW), or Metallic Arc (SMAW) process. Filler wire of ELC grades only shall be added to all welds to provide a cross section at the weld equal to or greater than the parent metal. Weld deposit shall be greater than the parent metal. Weld deposit shall be smooth and evenly distributed and have a crown of no more than 1/16 inch on the I.D. and 3/32 inch on the O.D. of the piping or fittings. Concavity, undercut, cracks, or crevices shall not be allowed. Butt-welds shall have full penetration to the interior surface, and inert gas shielding shall be provided to the interior and exterior of the joint. Excessive weld deposits, slag, spatter, and projections shall be removed by grinding. Angle face rings shall be continuously welded on both sides to the pipe or fitting. Welds on gasket surfaces shall be ground smooth.

K. All fittings shall be welded with 304L filler metal. All elbows through 24-inch size shall be long radius, die-formed, and shall be automatically butt welded in accordance with ASTM A774 of the same material and thickness as the pipe using gas tungsten-arc procedures with inert gas backing. Tees, crosses, true wyes, and laterals shall be shop-fabricated. All short radius, special radius, and reducing elbows and long radius elbows greater than 24-inch shall be mitered construction with at least (5) miter sections for 90-degree bends, (3) mitered sections for 45-degree and 60-degree bends, and (2) mitered sections for 30-degree and smaller bends. All reducers shall be straight tapered, cone-type. Longitudinal welds on all fittings, except elbows, shall be accomplished by the same procedures as listed for pipe. Weld seams shall have full penetration and be free of oxidation, crevices, pits, cracks, and protrusions. Fitting dimensions shall be in accordance with ANSI B16.9 and shall be terminated and dimensioned as indicated on the Drawings.

L. Pipe spools shall be manually welded with 304L filler metal using gas tungsten-arc procedures with internal gas purge where internal weld seams are not accessible. Where they are accessible, seams shall be welded both inside and outside using manual shielded metal-arc procedures. Weld seams shall have full penetration and shall be free of oxidation, crevices, pits, cracks, and protrusions.

M. All pipe, fittings, and spools shall be completely pickled and passivated by immersion in a nitric-hydrofluoric bath at the proper temperature and length of time to insure removal of all free iron, weld scale, and other impurities and to ensure the establishment of a passive surface. A clean water rinse shall follow the acid pickle.

N. The inspection of all welds shall be required. This shall be a visual inspection for crevices, pits, cracks, protrusions, and oxidation deposits. Presence of any of these items found in the weld seams shall be considered as grounds for rejection of the joint.

O. All fabricated piping shall have openings plugged and flanges secured for storage and/or transport after fabrication. All fabricated piping shall be piece marked with identifying numbers or codes which correspond to the Contractor's layout and installation drawings. The marks shall be located on the spools at opposite ends and 180 degrees apart.

P. The piping supplier during manufacturing, fabrication, and handling stages and the Contractor during handling and installation stages shall use extreme care to avoid the contact of any ferrous materials with the stainless steel piping. Only manufacturer recommended saws, drills, files, wire brushes, etc. shall be used for stainless steel piping. Pipe storage and fabrication racks shall be non-ferrous or stainless steel or rubber-lined. Nylon slings or straps shall be used for handling stainless steel piping. Contact with ferrous items may cause rusting of iron particles embedded in the piping walls. After installation, the Contractor shall wash and rinse all foreign matter from the piping surface. If rusting of embedded iron occurs, the Contractor shall pickle the affected surface with Oakite Deoxidizer SS or equal, scrub with stainless steel brushes, and rinse clean.

2.02 PROCESS AIR PIPE SUPPORT AND EXPANSION/CONTRACTION SYSTEM

A. The process air pipe support and expansion/contraction system shall include fixed supports, sliding supports, and expansion joints. Expansion joints shall be either a split sleeve expansion coupling or a metal bellows expansion joint as indicated on the Drawings. A metal bellows expansion joint shall be provided for all expansion joints, unless otherwise indicated on the Drawings.

B. The air pipe support and expansion/contraction system shall consist of expansion joints at the locations shown on the Drawings, with one fixed support between each pair of expansion joints. Fixed support details shall be as shown on the Drawings. Additional air pipe supports shall be sliding supports as shown on the Drawings and according to the support spacing requirements indicated and/or scheduled on the Drawings. Sliding and fixed support details shall be as shown on the Drawings.

C. Expansion couplings shall be bolted split-sleeve Style 231S as manufactured by Victaulic Company, or equal. Couplings shall be installed where shown on the Drawings and as specified in the following table, in accordance with the manufacturer's recommendations for the specific application. Expansion couplings shall be provided at each insert flow tube. Initial gap width (space between plain ends of joining pipes) shall be set based on recommendations from the manufacturer. The body "type" shall be as required to meet the working pressure indicated.

Nominal Pipe Size (inch)	Coupling	Width "W" (inch)	Longitudinal Movement (C/E) (inch)
3 to 4	Type 1 Style 231 S	5.25	0.75
6	Type 1 Style 231 S	8	1.25
8 to 14	Type 1 Style 231 S	10	1.50
16 to 24	Type 1 Style 231 S	14.38	2.00
30 to 48	Type 2 Style 231 S	14.38	2.00
Greater than 48	Type 2 Style 231 S	16.38	3.00

1. Couplings shall be suitable for a pressure of 25 psig and a temperature of 300 degrees Fahrenheit, at minimum. The design "delta" or change in temperature shall be a minimum of 250 degrees Fahrenheit.

2. Couplings shall be bolted, split-sleeve type and shall consist of four components: one-piece housing, gasket assembly, bolts and nuts, and end rings as required for pipe restraint. Gasket material shall be Viton or silicone.

3. Couplings shall be manufactured from Type 316L stainless steel using 316 stainless steel bolts and nuts with a minimum tensile strength of 85,000 psi. End rings shall be Type 316L stainless steel. End rings shall be shop-welded to one end of one pipe installed in the coupling.

4. Couplings shall be provided and installed as specified and shown on the Drawings.

5. The gap, "G", between ends of pipe shall be initially set and installed based on width of required clear space and the ambient temperature at the time of installation in conformance with requirements provided by manufacturer accounting for the required design movement allowance as specified for contraction and expansion of pipe.

D. All other air pipe expansion joints and/or where indicated on the Drawings shall be stainless steel bellows type expansion joints by DME Incorporated, Hyspan Precision Products, Inc., Omniflex by Victaulic, or equivalent coupling by U.S. Bellows, Inc., as specified and indicated on the Drawings. Laying lengths of expansion joints vary according to manufacturer. Lengths of expansion joints shown on the Drawings are approximate. Contractor shall provide dimensioned layout drawings for air piping based on the expansion joints ultimately furnished.

1. Expansion joints shall be metal bellows type with fixed flanged end preparations with a stainless steel internal flow liner. The joints shall provide for a minimum of 2 inches of axial movement in either direction for air pipe sizes 4 to 6 inches in diameter and a minimum of 3.5 inches of axial movement in either direction for all pipe sizes 8 inches and larger. Joints shall provide for a minimum lateral movement of 1/2 inch for all sizes. Number of convolutions shall be determined by the manufacturer based on movement requirements specified and a cycle life of 2,000 or more. The flanges shall meet the same thickness and class requirements as required for the joining stainless steel pipe.

2. Joints shall be suitable for a pressure of 25 psig and a temperature of 300 degrees Fahrenheit, at a minimum. The design "delta" or change in temperature shall be a minimum of 250 degrees Fahrenheit.

3. Joint and flanges shall be manufactured from Type 316L stainless steel using Type 316 stainless steel bolts and nuts with a minimum tensile strength of 85,000 psi. Coupling shall have an air service liner welded on the upstream side of the bellows.

4. The length of bellows, number of convolutions, and spacing between flanges shall be designed and installed accounting for the ambient temperature at the time of installation, which shall accommodate the full range of expansion and contraction movements as specified.

5. Required "cycle life" shall be a minimum of 2,000 based on "Expansion Joint Manufacturers Association" (EJMA) criteria, 10th Edition or later.

6. Metal bellows expansion joints shall be restrained using limit rods bolted between flange tabs. All material shall be Type 316L stainless steel. The limit rods and connecting tabs, including flanges, shall be designed by the manufacturer for the maximum loading condition.

7. Joints required for buried pipe shall be installed within a handhole or manhole as indicated on the Drawings. No backfill of any nature or material shall be placed against, under or over the joint.

2.03 EXTERIOR PAINTING AND TAPE WRAP FOR BURIED STEEL PIPE

A. Except for areas of pipe to be welded, the exterior of buried steel and stainless steel pipe shall receive a prime coat of 6 to 10 mils (dry) of an epoxy-phenolic or epoxy-amine primer service rated for -50ºF to 300ºF continuous service and shall be Thermaline 450 EP as manufactured by Carboline, Carbomastic 15 as manufactured by Carboline, TC 7000 as manufactured by Chase/Tapecoat, or equal. The primer product used shall be compatible with the exterior tape system manufacturer recommendations.

B. Areas of pipe to be welded shall receive 1 mil (dry) of weldable primer as manufactured by Carboline, or equal. After welding and pressure and leakage testing are completed, welded joints shall be thoroughly cleaned of all foreign matter and any scale or rust and primed as specified above.

C. The exterior of buried steel pipe shall receive, over the prime coat, a multi layered, cold applied tape wrap system which shall be shop applied with a minimum total coating thickness of 80 mils. The cold applied type wrap shall operate satisfactorily at a

temperature of 300ºF.

D. The wrap shall be applied in accordance with manufacturer's recommendations and as specified herein. All fittings shall be wrapped in accordance with manufacturer's recommendations. Successive layers shall be applied such that windings are staggered and overlay the midpoints of previous tape widths. Prime coat and wrap shall be applied to each joint as specified for the pipe for continuous coating and wrapping of all buried steel and stainless steel piping. Polyethylene backed coatings shall be protected from sunlight at all times. The tape wrap system shall be the Tapecoat HT/MB 300ºF Coating System as manufactured by the Chase Tapecoat, Evanston, Illnois, or equal.

PART 3 -- EXECUTION

3.01 FIELD WELDING OF STAINLESS STEEL PIPING AND FITTINGS

A. Contractor shall minimize the amount of field welding of stainless-steel piping required. Locations for pipe field welding will be evaluated and allowed on a case-by-case basis upon written approval of the Engineer. All field welding of stainless steel pipe is subject to the following requirements:

1. Welding shall be performed by AWS-certified welders in conformance with AWS 1.6. Submit welder's certification for approval prior to performing any field welding.

2. Piping with wall thickness up to 11 gauge (0.125-inch) shall be welded with the TIG (GTAW) process. Heavier walls shall be properly beveled and have a root pass with the TIG (GTAW) process followed by subsequent passes with the TIG (GTAW) or MIG (GMAW) process. Filler wire of ELC grades only shall be added to all welds to provide a cross-section at the weld equal to or greater than the parent metal. Weld deposit shall be greater than the parent metal. Weld deposit shall be smooth and evenly distributed and have a crown of no more than 1/16 inch on the I.D. and 3/32 inch on the O.D. of the piping or fittings. Concavity, undercut, cracks, or crevices shall not be allowed. Butt-welds shall have full penetration to the interior surface. Excessive weld deposits, slag, spatter, and projections shall be removed by grinding.

3. Jigs shall be utilized to align adjacent sections of piping.

B. Post-Weld Treatment:

1. All field welds shall be wire brushed utilizing steel or stainless steel wire brushes to remove slag and spatter. Stainless steel brushes shall be used on stainless steel pipe.

2. The weld and the heat affected area shall be pickled with a brush-on pickling gel in accordance with ASTM A380 to remove all weld residue, oxide, and heat stain from the field weld and affected areas.

3. Pickling of stainless steel pipe shall be done in accordance with pickling paste manufacturer's directions, and areas being pickled shall be protected from direct sunlight. After pickling period is complete, neutralize pickling gel in accordance with directions and rinse area clean.

C. Where field welding of stainless steel piping is approved by the Engineer, all field welds shall be visually inspected and tested by an approved quality assurance testing firm in accordance with AWS D1.1, AISC Design Guide 21 Welded Connections, Section 9.0 and other applicable referenced sections of AWS and AISC. The Contractor shall be responsible for contracting with an approved testing firm. Nondestructive testing methods shall be used unless otherwise approved by the Engineer. The Contractor shall submit a proposed testing firm and personnel for approval in addition to his proposed plan to visually inspect and test all field welds of steel pipe prior to field welding of steel pipe.

3.02 FLUSHING AND TESTING

A. Flushing and testing of all installed low pressure air piping shall be performed as specified in Section 15000 – Basic Mechanical Requirements. The field testing procedure for process air piping shall use air pressure only.

- END OF SECTION -

SECTION 15020

PIPE SUPPORTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all equipment, labor, materials, and design calculations required to provide pipe supports in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01350 – Seismic Anchorage and Bracing

B. Division 3, Concrete – Appropriate and Related Sections

C. Division 5, Metals – Appropriate and Related Sections

J. Section 15000 – Basic Mechanical Requirements

1.02 SUBMITTALS

A. Applicable and associated cut sheets and drawings for materials and support components shall be submitted with the Shop Drawings in accordance with or in addition to the submittal requirements specified in Section 01300 – Submittals: Section 15000 - Basic Mechanical Requirements and other referenced Sections above.

1. Catalog cut information on all system components such as pipe supports, hangers, guides, anchors, and channel-type supports.

2. Drawings of the piping support systems, locating each support, brace, hanger, guide, component and anchor. Identify support, hanger, guide and anchor type by catalog number and Shop Drawing detail number.

3. With each piping support system Shop Drawing, the Contractor shall attach calculations prepared and sealed by a Professional Engineer licensed in the State of South Carolina showing that the piping support system complies with the specified requirements, including all building code and seismic code requirements pertaining to support of piping and other non-structural components. See Section 01350 – Seismic Anchorage and Bracing.

1.03 QUALITY ASSURANCE

A. Piping support systems shall be designed, and Shop Drawings prepared and sealed by a Professional Engineer licensed in the State of South Carolina.

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PART 2 – PRODUCTS

2.01 GENERAL

A. The Contractor shall be responsible for the design of all piping support systems not specifically designed by the Engineer and detailed on the Drawings. The supports typically detailed on the Drawings, not included on Standard Detail Drawings, are designed to resist resulting external thrust forces in addition to gravity, seismic and other applicable loads required by the governing building code.

B. No attempt has been made to show all of the required pipe supports either on the main Drawings or on the standard detail drawings. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility of providing them throughout the project at no additional cost to the Owner.

C. Where special pipe support fabrications are required, products and execution shall be as specified in Section 05500 - Metal Fabrications and other related and referenced Sections of the Specifications.

D. Existing piping support systems to support new piping shall only be used if the Contractor can show and demonstrate by submitting supporting calculations that they are adequate for the additional load imposed by the new piping, or if they are strengthened to support the additional load.

E. Design Criteria for Piping Support Systems:

1. Design pipe supports for dead loads imposed by the weight of the pipes filled with water, except for air and gas pipelines, plus the weight of insulation. If applicable by location, ice loads per code shall be applied as indicated in the governing building code.

2. Design for the thermal expansion and contraction of the piping and its associated pipe support and pipe expansion systems and couplers.

3. Design the pipe supports for all seismic loading requirements and conditions as specified in the governing building code and referenced seismic design codes. Refer to Section 01350 - Seismic Anchorage and Bracing and the structural code drawing for seismic design criteria to be used for this particular project.

4. A minimum safety factor of 2 or as approved by the Engineer, based upon the yield strength of the support material, shall be used for pipe supports, braces, hangers, and guides as well as for beam and column members used in channel-type support systems.

5. The horizontal pipe hanger and/or floor support spacing shall be as recommended by the pipe and/or hanger manufacturer but shall not exceed 10 feet on center unless indicated otherwise herein or on the Drawings.

6. Seismic and sway bracing shall be provided at maximum 10-foot centers.

7. The design, sizing and spacing of anchor bolts, including concrete anchors, shall be based on withstanding shear and pullout loads imposed by loading at each particular support. The minimum anchor bolt size shall be ½ inches in diameter. Refer to Section 05830 – Bearing Devices and Anchoring.

2.02 HANGERS AND SUPPORTS

A. All piping shall be adequately supported and braced by means of steel hangers and/or supports, concrete piers, supplemental lateral bracing components, pre-fabricated brackets, or otherwise as may be required by the location and forces applied per governing code, including gravity and lateral forces from earthquake and/or wind (if exterior). Generally, concrete supports shall be used where pipe centerline is less than 3 feet above floor, and hangers above 6 feet unless specified or shown otherwise. Supports shall be not more than 10 feet on center for steel and cast iron, 5 feet on center for plastic unless otherwise shown on the Drawings or required by the specific manufacturer. All necessary inserts or appurtenances shall be furnished and installed in the concrete or structures for adequately securing hangers and supports to the structure. Refer to Standard Detail Drawings.

1. Metal pipe support materials, where stainless steel pipe is supported, shall be Type 304 stainless steel meeting the requirements of Section 05061 - Stainless Steel.

2. Metal pipe support materials, where carbon steel, ductile or other ferrous pipe is supported, shall be galvanized carbon steel meeting Section 05120 - Structural Steel and Section 05035 - Galvanizing unless indicated otherwise on the Drawings or in the specifications or by the Engineer.

3. Metal pipe supports indicated as standard type pipe hangers are designed and detailed for gravity loading only. Resulting lateral loads from wind, earthquake, or other lateral loads per code, or special loading conditions during construction, shall be applied to the pipe in accordance with the governing building code. Supplemental lateral stiffening members (when necessary) shall be provided along pipe or at gravity supports using appropriate supplemental members and connections when required by calculations. The Contractor shall include design calculations and details with all pipe hangar and support submissions for review by the Engineer. The main structure and structural components that will support the pipe hangers and other appurtenant components of the facility have been designed to resist all resulting secondary lateral loading from pipe hangers and other non-structural members for gravity and resulting lateral loads.

B. Hangers and supports shall conform to the following requirements:

1. All fabricated metal hangers and supports shall be capable of adjustment after installation. Different types of hangers and supports along a pipe length, including bends, shall be kept to a minimum.

2. Hanger rods shall be straight and vertical. Chain, wire, strap, or perforated bar hangers shall not be used. Hangers shall not be suspended from other piping.

3. Vertical piping shall be properly supported at each floor and between floors by stays or braces to prevent rattling and vibration.

4. Supports and hangers for plastic and FRP piping shall include wide saddles or bands as recommended by the manufacturer and approved by the Engineer to distribute load and thus avoid localized deformation of the pipe.

5. Hanger and supports shall prevent contact between dissimilar metals by use of copper plated, rubber, vinyl coated or stainless-steel hangers.

6. Ferrous pipes to be painted shall be painted in accordance with Section 09900 - Painting. Ferrous pipes that require painting or galvanizing shall be supported by galvanized hangers and supports. Stainless steel piping shall be supported by stainless steel saddles and straps (if required).

7. Copper piping shall be supported by plastic coated or copper plated steel hangers and supports.

8. Plastic piping shall be supported by plastic coated steel hangers and supports.

9. Hangers and supports shall provide for thermal expansion throughout the full operating temperature range.

10. Expansion and adhesive type anchors used for pipe hangers and supports shall be Type 304 stainless steel.

C. Metallic hangers and supports may be standard make by Anvil International, Inc., "Witch" by Carpenter & Paterson, Ltd., B-Line Systems, Inc., or equal; and data on the types and sizes to be used shall be furnished to the Engineer for approval. Metallic support system brackets, rods, support clips, clevis hangers, hardware, etc. shall be cast iron or welded steel construction. All gravity type hangers and supports shall be restrained laterally to resist seismic loading and other loading as required by the governing code.

D. Non-metallic support system shall be a heavy-duty channel framing system. Channel frames shall be manufactured by the pultrusion process using corrosion grade polyester or vinylester resins. All fiberglass construction shall include suitable ultraviolet inhibitors for UV exposure and shall have a flame spread rating of 25 or less per ASTM E84. Piping accessories, pipe clamps, clevis hangers, support posts, support racks, fasteners, etc., shall be constructed of vinylester or polyurethane resin. Non-metallic support systems shall be standard make Aickinstrut by Aickinstrut, Inc., Unistrut Fiberglass by Unistrut, Inc., Enduro Fiberglass Systems, or equal. The Contractor shall submit data on the types and sizes of approval. Unless otherwise shown or specified the Contractor shall provide support spacings in the conformance with the pipe and support system manufacturer's requirements.

2.03 PROCESS AIR PIPE SUPPORTS

A. Unless specifically designed and detailed on the Drawings, process air piping shall be supported by slide bearings as manufactured by Fluorocarbon Company, Anaheim, California, Anvil International, Inc., Portsmouth, New Hampshire, or equal. Refer to Section 05830 – Bearing Devices and Anchoring for supplemental information and requirements.

B. The slide bearing material shall be 3/32-inch-thick, 25 percent glass-fiber reinforced structural grade teflon. The bearing material shall withstand at least 1000 psi (compression) at 250°F with a coefficient of friction between .05 and.08. The performance of bearing and bonding materials shall be unaffected by continual immersion in wastewater containing domestic and industrial waste at a temperature of 210°F.

C. Non-submerged slide bearing type supports shall be provided with a bearing material covering a 120° arc centered at the bottom of the pipe. The Teflon shall be at least 4 inches wide at the underside of the pipe and 8 inches wide at the top of the support. The Teflon material shall be hot press bonded to 10 ga. stainless steel plates for welding to the bottom of the pipe and securing to the top of the support.

D. Submerged slide bearing type supports shall be provided with Teflon bonded to the underside of the hold down strap and the top of the pipe such that the sliding surface is formed between two sheets of Teflon. Each surface shall cover a 120° arc centered at the top of the pipe. On the underside of the strap the Teflon bearing shall be hot press bonded directly to the stainless-steel strap or to a 10 ga. stainless steel plate for welding to the strap. At the top of the pipe, the Teflon shall be bonded to a 10 ga. stainless steel plate for welding to the pipe.

E. Pipe straps shall not tightly bind the pipe but shall provide 1/16-inch clearance over the top 180° of the pipe surface.

F. Wall bracket supports shall be used where shown for pipe to be installed adjacent to a wall. Where it is not feasible to install hanger supports, adjustable pipe saddle supports may be used with the permission of the Engineer. Concrete pier supports shall be spaced at a maximum distance of 10 feet and shall be at least 12” wider than O.D. of pipe and 10 inches thick unless otherwise shown on the Drawings. Refer to the Standard Detail Drawings.

G. Small diameter piping (6-inches in diameter or less) shall not be strapped or otherwise secured directly to walls. Suitable wall offset brackets of an approved type shall be used. Anchors shall not be attached using percussion fasteners.

H. Sliding surfaces shall be protected from accumulation of dirt, grit, or other foreign matter.

I. Slide bearings shall be capable of adequately supporting the design loads and shall be attached to pipe and supports as specified and recommended by the manufacturer.

J. The slide bearings shall be installed in the locations shown or indicated on the Drawings, at required elevations, true to orientation and level, assuring that the correct half of each bearing is in its proper position. The Contractor shall store the bearings to protect them from mechanical damage prior to installation and shall protect the same during and after installation from contamination and damage due to placing of concrete and other materials. The Contractor shall clean the operating surfaces of bearings thoroughly before final assembly.

K. The Contractor shall note that all pipe support locations are not shown on the Drawings and shall follow the Specifications herein in locating supports. Where deviations and modifications are required, they shall be made only with the permission of the Engineer. A detailed layout of pipe supports, and hangers shall be submitted for approval.

PART 3 -- EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Support piping connections to equipment by pipe support and not by the equipment.

B. Support large or heavy valves, fittings, flow meters and appurtenances independently of the connected piping.

C. Support no pipe from the pipe above it.

D. Support piping at changes in direction or in elevation, adjacent to flexible joints, expansion joints, and couplings, and where shown.

E. The Contractor shall not install piping supports and hangers in equipment access areas or bridge crane runs.

F. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing.

G. Install pipe anchors (fixed supports and/or guides) where shown and/or as may otherwise be required to withstand expansion thrust loads and to direct and control thermal expansion. The Contractor may install additional pipe anchors and flexible couplings to facilitate piping installation, provided that complete details describing location, pipe supports and hydraulic thrust protection are submitted.

- END OF SECTION -

SECTION 15095

VALVES, GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install, complete with all assemblies and accessories, all valves shown on the Drawings and specified herein including all fittings, appurtenances and transition pieces required for a complete and operable installation.

B. All valves shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. Except where noted otherwise, valves designated for water service shall conform to pertinent sections of the latest revision of AWWA C500 Specifications. Cast iron valve bodies and parts shall meet the requirements of the latest revision of ASTM Designation A-126, "Standard Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B."

C. All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.

D. Valves shall have flanged ends for exposed service and mechanical joint ends for buried service, unless otherwise shown on the Drawings or specified herein. Flanged ends shall be flat-faced, 125 lb. American Standard unless otherwise shown or specified in accordance with ANSI B16.1. All bolt heads and nuts shall be hexagonal of American Standard size. The Contractor shall be responsible for coordinating connecting piping. Valves with screwed ends shall be made tight with Teflon tape. Unions are required at all screwed joint valves.

1.02 SUBMITTALS

A. The Contractor shall furnish to the Owner, through the Engineer, a Performance Affidavit where required in individual valve specifications, utilizing the format specified in Section 11000, Equipment General Provisions. Performance tests shall be conducted in accordance with the latest revision of AWWA C500 and affidavits shall conform to the requirements of the Specifications

B. Shop Drawings conforming to the requirements of Section 01300, Submittals, are required for all valves, and accessories. Submittals shall include all layout dimensions, size and materials of construction for all components, information on support and anchoring where necessary, pneumatic and hydraulic characteristics and complete descriptive information to demonstrate full compliance with the Documents. Shop Drawings for electrically operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the electrical power supply and remote status and alarm indicating devices. Electrical control schematic diagrams shall be submitted with the Shop Drawings for all electrical controls. Diagrams shall be drawn using a ladder-type format in accordance with JIC standards. Shop Drawings for pneumatically operated/controlled valves

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shall include all details, notes, and diagrams which clearly identify required coordination with the compressed air (service air) system and electrical controls.

C. Operation and maintenance manuals and installation instructions shall be submitted for all valves and accessories in accordance with the Specifications. The manufacturer(s) shall delete all information which does not apply to the equipment being furnished.

1.03 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor shall provide the services of a qualified representative of the manufacturer(s) of the equipment named below to check out and certify the installation(s), to supervise the initial operation, and to instruct the Owner's operating personnel in proper operation and maintenance procedures in accordance with the following schedule:

Item	Valve/Operator Type	Minimum On-Site Time Requirements
1.	Automatic Control Check Valve	One (1) 8-hour day
2.	Surge Anticipators	One (1) 8-hour day
3.	Motor Operated Modulating Valves	One (1) 8-hour day
4.	Motor Operated Open-Close Valves (required only if manufacturer is other than for Item 3 above)	One (1) 8-hour day

B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.

C. A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies notes.

D. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

PART 2 -- PRODUCTS

2.01 QUICK DISCONNECT COUPLINGS

A. Quick disconnect type coupling for compressed/service air shall be provided where indicated on the Drawings. Coupling shall provide for instantaneous shutoff in socket end when lines are disconnected. Couplings shall be constructed of 316 stainless steel with a BUNA-N O-ring and integral safety lock. Couplings shall comply with Military Specification 4109 (interchangeable with standard plug of the same size).

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Except where noted otherwise herein, all valves shall be installing and tested in accordance with the latest revision of AWWA C500. Before installation, all valves shall be lubricated, manually opened and closed to check their operation and the interior of the valves shall be thoroughly cleaned. Valves shall be placed in the positions shown on the Drawings. Joints shall be made as directed under the Piping Specifications. The valves shall be so located that they are easily accessible for operating purposes and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.

B. All valves shall be tested at the operating pressures at which the particular line will be used. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight. All motor operated valves shall be tested for control operation as directed by the Engineer.

C. Provide valves in quantity, size, and type with all required accessories as shown on the Drawings.

D. Install all valves and appurtenances in accordance with manufacturer's instructions. Install suitable corporation stops at all points shown or required where air binding of pipe lines might occur. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor but without interfering with access, and as approved by Engineer. Unless otherwise approved, install all valves plumb and level. Valves shall be installed free from distortion and strain caused by misaligned piping, equipment or other causes.

3.02 SHOP AND FIELD TESTING

A. Shop and field testing of valves shall be as follows:

1. Certified factory testing shall be provided for all components of the valve and operator system. Valves and operators shall be shop tested in accordance with the requirements in the latest revision of AWWA C500, including performance tests, leakage test, hydrostatic tests, and proof-of-design tests. The manufacturer through the Contractor shall submit certified copies of the reports covering the test for acceptance by the Engineer.

2. Shop testing shall be provided for the operators consisting of a complete functional check of each unit. Any deficiencies found in shop testing shall be corrected prior to shipment. The system supplier through the Contractor shall submit written certification that shop tests for the electrical/pneumatic system and all controls were successfully conducted and that these components provide the functions specified and required for proper operation of the valve operator system.

3. The Contractor shall conduct field tests to check and adjust system components, and to test and adjust operation of the overall system. Preliminary field tests shall be conducted prior to start-up with final field tests conducted during start-up. The factory service representative shall assist the Contractor during all field testing and prepare a written report describing test methods, and changes made during the testing, and summarizing test results. The service representative shall certify proper operation of the valve operator system upon successful completion of the final acceptance field testing.

4. Preliminary and final field tests shall be conducted at a time approved by the Engineer. The Engineer shall witness all field testing.

5. All costs in connection with field testing of equipment such as energy, light, lubricants, water, instruments, labor, equipment, temporary facilities for test purposes, etc. shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.

6. Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components. Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly. The preliminary field test report must be approved by the Engineer prior to conducting final field acceptance tests. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation specified or otherwise directed by the Engineer.

7. Final field acceptance tests shall be conducted simultaneously with the start-up and field testing of the pumps, air compressors, process air blowers, etc. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing. Performance of pneumatic valves and compressed air system under normal operating conditions and during simulated power failures shall be checked.

8. Field testing shall include optimization of opening and closing times of the valves. The Contractor shall provide the means for accurate measurement of pipeline pressures as directed by the Engineer. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

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SECTION 15101

BUTTERFLY VALVES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Reference Section 15000, Basic Mechanical Requirements.

PART 2 -- PRODUCTS

2.01 BUTTERFLY VALVES (LOW PRESSURE PROCESS AIR)

A. Isolation valves and throttling valves for low pressure (less than 25 psig) air service shall be resilient-seated butterfly valves as manufactured by Centerline (Crane), Bray, or Dezurik. All valve components shall be suitable for continuous operation at temperatures up to 250°F with a 25 psig minimum working pressure. Materials of construction shall be as specified below.

1. Valve bodies – Ductile Iron
2. Valve discs and shafts – 316 stainless steel
3. Valve seals – EPDM, PTFE or Viton (as required to meet the above temperature requirements)

B. Valves less than 30 inches shall be flanged or have a wafer or lug style body and be compatible with ASME B16.1 flanges. The Contractor shall coordinate flange connections upstream and downstream of wafer valves. Valves 30 inches or larger shall have flanged end connections conforming to ASME B16.1, 125-pound rating.

C. Manually operated isolation valves shall be provided with a handwheel or chainwheel, as required and/or as shown on the drawings, operator and shall provide for tight shut-off. A mechanical dial indicator shall be provided on the operator to continuously indicate valve positions. Where specified and/or as shown on the drawings, the Contractor shall provide motor actuators meeting the requirements of Specification Section 15100. Motor actuators for throttling valves shall provide for modulating operation. Cycle time from full open to full closed shall be approximately 60 seconds. 4-20 ma position feedback signals shall be provided for each actuator. Contractor shall wire 4-20 ma position signals to the PLC.

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SECTION 15108

GATE VALVES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Reference Section 15000, Basic Mechanical Requirements.

PART 2 -- PRODUCTS

2.01 GATE VALVES

A. Gate valves 4 inches through 16 inches shall be of the non-rising stem design, shall fully comply with the requirements of AWWA C509 for resilient-seated gate valves and shall be the Metroseal 250 as manufactured by U.S. Pipe and Foundry Co., or equal. Gate valves shall be designed for a minimum working pressure of 250 psi and a test pressure of 500 psi.

B. Gate valve body and bonnet shall be cast iron conforming to ASTM A126, Class B with resilient seat gate and O-ring seals. The gate shall be cast iron with a vulcanized rubber coating with no metal to metal contact when in the fully closed position and a smooth unobstructed waterway when in the fully opened position. Gate valves 18 inches and larger shall fully comply with the requirements of AWWA C500 and shall be double disc parallel seat with bypass and inside screw spur geared operator, unless otherwise specified or shown on the Drawings. Valves shall be American Darling Series 50, Mueller, or equal.

C. Valves shall be flanged mechanical joint as shown on the Drawings, with non-rising stems, and with a 2-inch square standard AWWA operating nuts unless otherwise shown on the Drawings or specified herein.

D. All internal ferrous components and surfaces of the valves, with the exception of stainless steel and finished or bearing surfaces, shall be shop painted with two coats (10 mils min. dry film thickness) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations.

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SECTION 15200

GATE OPERATORS AND ELECTRIC GATE ACTUATORS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. Equipment shall be provided in accordance with the requirements of Section 11000 – Equipment General Provisions and Section 15000 – Basic Mechanical Requirements.

B. Reference Section 15390 – Schedules for additional information on gates and operators/actuators.

C. The electric gate actuators shall meet the signal requirements described in Specification 17060 – Signal Coordination Requirements, 17920 – Control System Input/Output Schedule, and 17950 – Functional Control Descriptions.

D. Gate operators and electric gate actuators shall be designed to unseat, open or close, and seat the gate under the most adverse operating condition to which the gates will be subjected.

E. Operator mounting arrangements shall be as indicated on the Drawings or as directed by the manufacturer and/or Engineer. There shall be no mounting restrictions on the electric gate operator.

F. The gate operators and electric actuators shall be the full and undivided responsibility of the gate manufacturer in order to ensure complete coordination of the components and to provide unit responsibility.

1.02 SUBMITTALS

A. The following items shall be submitted with the Shop Drawings in accordance with, or in addition to the submittal requirements specified in Section 01300, Submittals; and Section 11000, Equipment General Provisions:

1. Certification that the force required to operate all gates is as specified herein.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Electric actuators shall be provided where specified in the Gate Schedules in Section 15390 – Schedules. Manual operators shall be provided on all gates which do not receive electric actuators.

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B. Manual operators and electric actuators shall be mounted on either a floorstand or a benchstand as specified in the Gate Schedules in Section 15390 and as shown on the Drawings.

1. Floorstands shall consist of a cast iron pedestal designed to position the input shaft or handwheel approximately 36-inches above the operating floor. Floorstands shall be of the straight or offset design as specified herein or as shown on the Drawings.

2. Benchstands shall be provided with a rectangular cast iron base machined and drilled for mounting purposes.

C. All operators/actuators shall be provided with a clear, butyrate plastic rising stem cover which shall not discolor or become opaque for a minimum of five (5) years after installation.

1. "Fully Open" and Fully Closed" positions shall be marked on each cover with mylar labels.

2. Covers shall be graduated in one (1) inch increments.

3. The top of the stem cover shall be closed and the bottom shall be mounted in an adapter plate or housing for easy field mounting to the gear housing.

2.02 MANUAL OPERATORS

A. Manual operators shall be provided by the gate manufacturer. Manual operators shall be handwheel or handcrank operated as indicated on the Drawings and specified in the Gate Schedule.

1. Manual operation shall require no greater than a 40 pound pull on the crank or handwheel with the specified operating head on the gate.

2. Manual operators shall be provided with a threaded cast bronze lift nut to engage the operating stem. Tapered anti-friction roller or ball thrust bearings shall be provided above and below a flange on the operating nut to support both opening and closing thrusts.

3. Lubricating fittings and extensions shall be provided for the lubrication of all gears and bearings.

4. An arrow with the word "open" shall be permanently attached or cast on the floorstand, benchstand, or handwheel indicating the direction of rotation to open the gate. Unless otherwise noted, all operators shall turn counter-clockwise to open.

5. All sluice gates and slide gates 3 ft. wide and larger shall be crank-operated, unless otherwise indicated herein as shown on the Drawings.

B. Handwheel operators shall be furnished without gear reduction. The removable handwheel shall be fabricated steel or cast iron, designed for rough treatment and minimum weight. Handwheels shall not be less than 12 inches in diameter. The maximum diameter of any handwheel shall not exceed 24”.

C. Crank-operated type manual operators shall have either single or double gear reduction depending upon the lifting capacity required.

1. Crank operators shall be suitable for operation by a portable gate operator.

2. Gearing shall be steel or cast iron with machine cut teeth designed for smooth operation.

3. The pinion shafts on crank-operated floorstands, either single or double, shall be stainless steel, and supported on tapered roller bearings.

4. All components shall be totally enclosed in a cast iron weather-proof housing with cover.

5. Positive mechanical seals shall be provided on the operating nut and the pinion shafts where they extend from the cast iron case or gear box to retain lubricant and to exclude moisture and dirt.

6. The removable crank shall be cast iron with a revolving brass grip.

2.03 ELECTRIC GATE ACTUATORS

A. Electric Actuators shall be open/close service or modulating service as specified in the Gate Schedule in Section 15390 – Schedules.

1. Open/Close (non-modulating) gate actuators shall be IQ series as manufactured by Rotork, SA series as manufactured by AUMA, or Series 2000 as manufactured by EIM Controls.

2. Modulating gate actuators shall be Type IQM as manufactured by Rotork, Type SAR as manufactured by AUMA, or Series 2000 Futronic as manufactured by EIM Controls.

B. Performance Requirements

1. The actuators shall be designed for indoor and outdoor service and shall be capable of mounting in any position.

2. Torque capacity of the actuators shall be sufficient to operate the gates with the maximum pressure differential, as indicated in the Gate Schedule in Section 15390, with a safety factor of 1.5. Actuators in modulating service will be selected such that the required dynamic gate torque is no more than 60% of the electric actuator's maximum rated breakaway of torque.

3. The electric actuator shall provide for a gate travel speed of 12" per minute unless otherwise approved by Engineer.

4. Actuators shall be capable of operating in ambient temperatures ranging from 0 degrees F – 160 degrees F.

5. For open/close (non-modulating) actuators, the gearing, motor and contactor shall be capable of 60 starts per hour without overheating.

6. For modulating actuators, the gearing, motor and contactor shall be capable of 1200 starts per hour without overheating.

C. The actuators shall include, in one integral housing, individual compartments for the motor, gearing, wiring terminals, and control circuits (including auxiliary switches plus position sensing device where required). The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal. The inner seal shall protect the motor and all other internal electrical elements of the actuator from entrance of moisture and dust when the terminal cover is removed. Double cartridge shaft seals shall be provided on the hand wheel and output shafts for weatherproof protection. All external fasteners shall be stainless steel. Compartments shall be provided with moisture and dust-proof rigid cast covers meeting NEMA 6, certified to submergence in 6 ft of water for 30 minutes. Actuators located in classified areas shall be suitable for use in Class 1, Division 1, Group D environments.

D. The actuators shall be provided with externally operable and lockable 480VAC circuit breakers integral to the control housing.

E. All gearing shall be hardened alloy steel or bronze and shall be rated at twice the output torque of the operator and shall be designed to withstand the stall torque of the motor without failure. Output drive gearing shall consist of a worm shaft and worm gear pinion operating in an oil bath. The worm gear pinion shall be alloy bronze. Worm gear drive shall be self-locking to prevent creeping of the gate in an intermediate position. Heavy-duty grease shall protect gearing and sealed ball bearings of the main shaft for five years without changing. Motor reduction gearing shall be spur or planetary gearing and shall allow for field repair and change in gear ratio.

F. A mechanical dial position indicator shall be furnished to continuously indicate the position of the gate at and between the fully open and fully closed positions. The indicator shall be driven by gearing driven off of the main worm gear pinion and shall operate when the actuator is in either the electrical mode or manual mode.

G. A handwheel shall be permanently attached for manual operation. A gear assembly shall be provided between the handwheel and the worm shaft if required to reduce the force necessary to operate the handwheel to less than 40 pounds. A positive declutch mechanism shall engage the handwheel when required. When the actuator is set in the declutched position for handwheel operation, it shall return automatically to electric operation when actuator motor is energized. The handwheel shall not rotate during electric operation nor shall a fused motor prevent handwheel operation.

H. The drive motor shall be specifically designed for actuator service and shall be characterized by high starting torque and low inertia. Motors shall be 460 volts, three phase, 60 Hz AC reversible squirrel cage induction type motors and shall be specifically designed for modulating service where indicated on the Gate Schedule in Section 15390. Motors shall be totally enclosed, non-ventilated, with NEMA Class F insulation minimum (Class H for modulating actuators) and a maximum continuous temperature rating of 120 degree C (rise plus ambient). A 120 VAC space heater shall be provided in the motor compartment. The electric motor shall have a time rating of at least 15 minutes at 104°F

(40°C) or twice the gate stroking time, whichever is longer, at an average load of at least 33% of maximum gate torque. Motor bearings shall be permanently lubricated by premium lubricant. The motor shall have plug and socket electrical connection to facilitate easy removal and replacement. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of gate travel with either phase sequence of the three-phase power supply connected to the actuator. The motor shall include single phase protection. A suitable thermal protection device shall be incorporated in the motor or motor starter circuits, connected to a tripping device. Fast acting fuses shall be provided to protect solid state components. The motor shall be capable of starting against the rated load in either the open or close direction when voltage to the motor terminals is plus or minus ten (10) percent of nameplate rating

1. Open/Close actuators shall be furnished with electro-mechanical reversing starters.

2. Modulating actuators shall be furnished with solid state reversing starters utilizing thyristors.

I. Leads from the motor shall be brought to the control circuit (limit switch) compartment without external piping or conduit box. An adequately sized space heater shall be installed in the control circuit compartment to aid in the prevention of damage resulting in from condensation. The following items shall be located in the control circuit compartment.

1. Torque limit switches shall be provided to de-energize the motor control circuit in the event of a stall when attempting to unseat a jammed gate and when torque is exceeded during gate travel. Each actuator shall have an open direction torque switch and a close direction torque switch. The torque switches shall be mechanically operated and able to be set in torque units. Torque switches shall be calibrated prior to the actuator's assembly to the gate.

2. Travel limit switches shall be provided to de-energize the motor control circuit when the actuator reaches the limits of travel in the open and close directions. The limit switch drive shall be of the counter gear type and "in step'" with the actuator output drive at all times in either the electrical or manual mode of operation. A minimum of six (6) contacts, three (3) normally open and three (3) normally closed, shall be supplied at each end of gate travel. Four (4) additional contacts shall be provided to report end of travel or any desired position between ends of travel.

J. Modulating actuators shall have a position feedback potentiometer mounted directly to the gate actuator gearing inside the gearing compartment. The potentiometer shall provide a 4-20 mA signal corresponding to gate position. Modulating gate actuators shall be designed to respond to either a 4-20mADC analog signal or a digital pulse signal as specified herein or as required to coordinate with the requirements of Division 17.

1. Modulating gate actuators designed to respond to a 4-20mADC signal shall be provided with a gate positioner which shall position the gate proportional to an externally generated 4-20mADC signal. The gate positioning control circuitry shall position the gate by comparing the command signal with the present gate position as indicated by the feedback potentiometer. The positioner shall be field adjustable to fail to the "open," "closed," or "last" position on loss of 4-20 mADC command signal.

2. Modulating gate actuators designed to respond to “pulse” open/close signals shall operate the gate during the time the open or close pulse signal is high. Modulating actuators designed to respond to “pulse” open/close signals shall have the latching circuitry described above for open/close actuators disabled.

K. The electrical terminals shall be housed in a double sealed terminal compartment isolated from the rest of the actuator components. The actuators shall be designed to operate from a single 480VAC, 3-phase source. The actuators shall be furnished with fuses inside of the terminal compartment. A quantity of two – ¾ inch NPT conduit entries shall be furnished.

L. Actuators shall contain wiring and terminals for the following control functions. All dry contacts shall be rated for 5A at 250VAC.

1. Open, Close, and Stop commands from external dry contacts (utilizing internal 24VDC power supply) and/or from an external signal of 12V to 120V. The inputs for the open, close, stop signals shall be field selectable to be respond to either maintained or momentary remote signals. In momentary mode, the actuator shall have internal latching circuitry that causes the operator to drive the gate to its limit of travel upon receipt of the momentary contact signal unless a stop signal is received.

2. Emergency override input from a normally closed or normally open contact. The actuator shall either open or close (field selectable) upon receiving the emergency override input.

3. Remote Local-Off-Remote selector switch, Open/Close pushbuttons, and Open/Closed pilot lights for a remote manual control station (see below). The remote Local-Off-Remote selector switch and Open/Close pushbuttons shall be a dry contact input to the actuator control circuitry. The Open/Closed pilot lights shall be powered from the gate actuator control power.

4. Four (4) unpowered contacts shall be provided which can be selected to indicate gate “Opened” and “Closed” position, “Remote” status of the actuator, and fail status of the actuator. The fail status contacts shall activate upon motor overtemperature and actuator overtorque as a minimum.

5. Terminals for 4-20mADC position command and 4-20mADC position feedback as described above for modulating actuators.

M. Local Controls

1. Actuators shall be furnished with a Local-Off-Remote selector switch; Open, Close, and Stop pushbuttons for local control; a red lamp indicating closed and a green lamp indicating open. L-O-R switch shall be padlockable in any of the three positions.

a. When the LOR is in the “Local” position, open/close control shall be by the open and close pushbuttons on the actuator. The stop push button shall stop the actuator travel.

b. When the LOR is in the “Off” position, the actuator shall not operate.

c. When the LOR is in the “Remote” position, the actuator shall be controlled by remote inputs from the PLC or from the remote manual controls station.

2. The local controls shall be arranged so that the direction of travel can be reversed without the necessity of stopping the actuator.

N. Remote Manual Control Station

1. Where indicated in the Gate Schedules in Section 15390 – Schedules, manual actuator controls shall be furnished in a separate NEMA 4X stainless steel enclosure (NEMA 7 if located in a classified area). Manual control station controls shall include Hand–Off-Auto Selector switch; Open, Stop, and Close pushbuttons; a red lamp indicating closed and a green lamp indicating open.

a. When the HOA is in the “Hand” position, open/close control shall be by the open and close pushbuttons on the remote manual control station. The stop push button shall stop actuator travel.

b. When the HOA is in the “Off” position, the actuator shall not operate.

c. When the HOA is in the “Auto” position, the actuator shall be controlled by remote inputs to the actuator from the PLC.

PART 3 -- EXECUTION

3.01 MANUFACTURER’S FIELD SERVICES

A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 11000, Equipment General Provisions and shall include the following site visits for electric actuators:

Service	**Number of Trips**	**Number of Days/Trip**
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

3.02 INSTALLATION

A. All gate actuators shall be installed in accordance with the manufacturer's published recommendations and the applicable specification sections for gates, and motor controls.

B. Gate actuators shall be factory coated in accordance with the manufacturer’s standard paint system.

3.03 SHOP TESTING

A. Shop testing shall be in accordance with Section 11000, Equipment General Provisions and with the following additional requirements:

1. Conduct a complete functional check of each unit. Correct any deficiencies found in shop testing prior to shipment.

2. Submit written certification that:

a. Shop tests for the electrical system and all controls were successfully conducted;

b. Electrical system and all controls provide the functions specified and required for proper operation of the gate operator system.

3. Each actuator shall be performance tested and individual test certificates shall be supplied free of charge. The test equipment shall simulate each typical gate load and the following parameters should be recorded:

a. Current at maximum torque setting

b. Torque at maximum torque setting

c. Flash Test Voltage

d. Actuator Output Speed or Operating Time

e. In addition, the test certificate should record details of specification, such as gear ratios for both manual and automatic drive, closing direction, and wiring diagram code number.

f. Verification of actuator torque rating with gate.

3.02 FIELD TESTS

A. Field testing shall be in accordance with Section 11000, Equipment General Provisions and with the following additional requirements:

1. Gate actuators shall be field-tested together with the associated gates.

2. Perform field tests to check and adjust system components, and to test and adjust operation of the overall system, in accordance with Section 11000.

a. Preliminary field tests shall be conducted prior to start-up.

b. Final field tests conducted during start-up.

3. Preliminary and final field tests shall be conducted at a time approved by the Engineer.

4. Test all gates at the operating pressures at which the particular line will be used.

5. Test all gates for control operation as directed.

6. Field testing shall include optimization of opening and closing times of the gates. Gate opening and closing times shall be adjusted based on process requirements to optimize operation of the gates. Final gate opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

B. Preliminary Field Tests

1. General: Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire gate operator system and all system components.

2. Scope: Preliminary field tests shall demonstrate that the gate operator system performs according to specifications and that all equipment, gates, controls, alarms, interlocks, etc., function properly.

3. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required gate closing time and operation, as specified or otherwise directed.

C. Final Field Tests

1. Final field tests shall be conducted in accordance with the latest revision of AWWA C500.

2. Final field tests shall be conducted simultaneously with the start-up and field testing of the pumps.

3. Final field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the gates shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.

4. Certification of Equipment Compliance: After the final field tests are completed and passed, submit affidavit according to Section 11000.

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SECTION 15204

SLIDE GATES AND SLUICE GATES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install all slide gates and stop plates complete with all accessories, special tools, spare parts, mountings, anchor bolts and other appurtenances as specified herein, as shown on the Drawings, and as required for a complete and operating installation.

B. Equipment shall be provided in accordance with the requirements of Section 11000 – Equipment General Provisions and Section 15000 – Basic Mechanical Requirements.

C. Locations, dimensions, design criteria, number required, etc. for slide gates and stop plates are indicated in the appropriate Schedule in Section 15390, Schedules.

D. Manual gate operators and electric gate actuators shall be as specified in Section 15200.

E. The Contractor shall coordinate all details, locations, clearances, and other conditions with the various equipment suppliers, so that the slide gates and stop plates function as part of a complete system.

F. All slide gates and sluice gates shall be the product of a single manufacturer.

1.02 WARRANTY AND GUARANTEE

A. Warranty and Guarantee shall be as specified in Section 11000.

B. The warranty period shall be for two (2) years.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Subject to compliance with the Specifications provide products manufactured by HydroGate, (No Exceptions).

B. Liberal safety factors shall be used in the design of all of the equipment. Working stresses shall not exceed the lower value of: One-third of the yield strength, or one-fifth of the ultimate strength of the material. The gates and appurtenances shall be designed for installation in the structures shown on the Drawings.

C. Stainless steel nameplates shall be permanently attached to each of the floorstands or benchstands indicating the invert elevation of the gate.

2.02 SLIDE GATES

A. Slide gates shall be fabricated stainless steel, self-contained, rising stem, designed to mount on the face of the concrete, or flush within the channel as detailed on the Drawings.

B. The guides shall be welded Type 316L stainless steel structural shapes.

1. The guides shall be designed for maximum rigidity, shall have a weight of not less than four pounds per foot, and shall be provided with holes for anchor bolts every 18-inches.

2. Guides shall be provided with ultrahigh molecular weight polyethylene bearing strips, minimum 3/8-inch thick, with an intrinsic viscosity of 14 or more by test, which shall reduce friction between the sliding disc and the frame.

3. The invert of the frame shall be an angle welded to the lower ends of the guides to form a seating surface for the resilient seal mounted on the disc.

4. Where the guides extend above the operating floor, they shall be sufficiently strong so that no further reinforcing is required.

5. Side guides shall be provided with a side mounted ruler to indicate height of the gate from above. Ruler shall be constructed of an aluminum plating with embedded markings at each half inch. Numerical markers shall be provided at each inch with smaller marks for each half inch. Numbers shall be large enough to be easily visible from the operating level above.

C. The yoke to support the handwheel operator shall be formed by two (2) angles welded at the top of the guides to provide a one (1) piece rigid frame. The arrangement of the yoke shall be such that the disc and stem can be removed without disconnecting the yoke.

D. The disc or sliding member shall be Type 316L stainless steel plate reinforced with Type 316L stainless steel structural shapes welded to the plate. The disc shall not deflect more than 1/720 of the span of the gate or 1/16-inch, whichever is smaller, under the design head specified. A specially molded resilient seal shall be mounted on the frame to provide flush bottom closure, where shown. The shape of the seal shall produce a seating surface having a minimum width of 3/4-inch, and the seal shall extend into the secondary slot of the guide. The vertical face of the seal shall be in contact with the seating surface of the guide to provide a proper seal at the corners.

E. All parts of the gate shall have a minimum thickness of 1/4-inch.

F. Operating stems shall be of Type 304 stainless steel, of a size to safely withstand, without buckling or permanent distortion, the stresses induced by normal operating forces. The stems shall be designed to transmit in compression at least 2-1/2 times the rated output of the operating mechanism with a 40-pound effort on the crank or handwheel.

1. Slenderness ratio (L/r) shall be less than 200.

2. The threaded portion of the stem shall have roled threads of the Acme type.

3. Stems of more than one section shall be joined by bronze or stainless-steel couplings threaded and keyed or bored and pinned, to the stems.

4. Keys or pins shall be corrosion resistant materials. All threaded and keyed couplings of the same size shall be interchangeable.

5. Clear polycarbonate stem covers shall be provided for all gates to allow visual indication of gate position, inspection of stem threads, and to protect the stem from contamination. Vent holes shall be provided to prevent condensation.

G. All slide gates shall be provided with an adjustable bronze stop collar on the stem above the floorstand or benchstand lift nut.

H. Stem guides shall be cast iron, bronze bushed, mounted on cast iron brackets. Guides shall be adjustable in two directions and shall be spaced in accordance with manufacturer's recommendations. Anchor bolts for stem guides shall be Type 316 stainless steel.

I. Materials of construction for gate discs, guides, frames, operators, and all appurtenances shall be as specified in Division 5 - Metals and the Gate Schedule. Methods of operation shall be as identified in the Gate Schedule.

J. Fabricated gates shall be substantially watertight under the design head conditions. Leakage shall not exceed 0.05 U.S. gallons per minute per foot (0.60 l/min per meter) of seal periphery under the design seating head and unseating head.

K. Sealing system shall consist of seals on the bottom, sides and top as required by the service and meeting the following requirements (if top of gate does not extend above high water level when closed, gate shall have top seal).

1. Guides shall be made of ultra-high molecular weight polyethylene (UHMWPE) and shall be of such length as to retain and support at least two thirds (2/3) of the vertical height of the slide in the fully open position. The guides shall be of a sandwiched type construction built of plates, angles and formed shapes. The guide slot shall engage the disc plate a minimum of 7/8".

2. Side and top seals shall be made of self-adjusting UHMWPE slides with a compression cord that shall ensure contact between the UHMWPE slide and the gate in all positions.

3. Sealing system shall maintain efficient sealing in any position of the slide and only let water flow in the open part of the gate.

4. Seals shall maintain the specified leakage rate in both seating and unseating conditions.

5. All upward opening gates shall be provided with a resilient seal to seal the bottom portion of the gate. The seal shall be attached to the invert member or the bottom of the slide and it shall be held in place with stainless steel attachment hardware.

6. All downward opening weir gates shall be provided with UHMW polyethylene seat/seals across the invert member.

2.03 SLUICE GATES

A. Sluice gates materials, construction, and performance shall be the same as for slide gates specified above, except as noted below.
B. The back flange of the frame shall bolt directly to the face of a wall thimble or pipe flange of a wall fitting, unless otherwise shown.

C. Wall thimbles shall be provided for all sluice gates, unless otherwise specified.

1. Designed for the corresponding design head conditions listed in the Gate Schedule.

2. Full wall depth "F" Type, "E" Type or Flange-Bell Type as indicated in the Gate Schedule or as shown on the Drawings.

3. Flush-mounted or as recommended by the sluice gate manufacturer.

4. For compatibility, all wall thimbles shall be supplied by the sluice gate manufacturer.

5. One-piece construction of adequate thickness and section to withstand all operational and installation stresses.

6. Thimbles shall be internally braced during installation.

7. A center ring or waterstop shall be cast around the periphery of the thimble.

8. The sluice gate mounting (front) flange shall be machined with tapped holes for the sluice gate attaching studs and have metal stamped vertical centerlines with the word "top" for correct alignment.

9. Type "E" thimbles shall be used to connect to piping and shall be machined with tapped holes for the connecting pipe flange attaching studs. Provide gaskets between stainless steel hardware and thimble to provide isolation between dissimilar metals.

10. Larger wall square-bodied thimbles shall be provided with holes in the invert to allow satisfactory concrete placement beneath the thimble.

11. A permanent gasket of uniform thickness shall be provided between the sluice gate and the wall thimble. Alternately, the gate manufacturer may provide precision machined mating surfaces between the gate frame and wall thimble and apply a mastic material to the surfaces in order to provide an acceptable seal. Regardless of the method used to seal the joint between the gate flange and the wall thimble, the final assembly shall meet the leakage criteria specified herein.

PART 3 -- EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 11000, Equipment General Provisions and shall include the following site visits for electric actuators:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	2
Startup and Training	1	4
Services after Startup	1	1

3.02 INSTALLATION AND TESTING

A. Installation - The slide gates shall be set carefully in the locations shown on the Drawings in accordance with the installation manual furnished by the gate manufacturer.

1. The stems shall be provided with wall-mounted guides where required.

2. Floorstands, and wall brackets shall be secured in place with adequately sized anchor bolts.

3. All gates shall be operated and tested to assure proper installation.

B. Testing - The completely assembled slide gates, in vertical position, shall be inspected for proper seating.

1. Seat facings shall be machined and wedges adjusted to exclude a 0.004-inch thickness gauge between the frame and disc seating surfaces.

2. The gate disc shall be fully opened and closed in its guide system to insure that it operates freely.

3. Floorstands shall be shop-operated to ensure proper assembly and operation.

C. All slide gates shall be certified that at the operating head conditions indicated on the Gate Schedule, leakage shall not exceed that specified in the latest version of AWWA C561 under seating and unseating head.

- END OF SECTION -

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SECTION 15290

INSULATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install insulation as shown on the Drawings or otherwise specified. Insulation shall not be installed until piping has been field tested and approved by the Owner. The Contractor shall protect the insulation from moisture at all times.

B. Reference Section 15000, Basic Mechanical Requirements.

PART 2 -- PRODUCTS

2.01 INSULATED AIR PIPING

A. Fiberglass insulation shall be provided for exposed exterior blower discharge piping as shown on the Drawings and as specified herein. Insulation shall be a roll of semi-rigid fiberglass board insulation. The fibrous insulation is adhered to the ASJ jacket with the end grain of the insulation perpendicular to the jacket surface. Each section of insulation may be secured on the longitudinal seam by using staples and mastic or vapor barrier ASJ pressure sensitive tape. Adjacent sections shall be butted together and sealed with vapor barrier ASJ tape. The insulation shall be 2-1/2 inches thick with a fiberglass density of at least 3 pounds per cubic foot.

B. Insulation for fittings and flanges shall be mitered segments of nominal 6 pounds per cubic foot density fiberglass pipe covering. Cover with a coat of insulating cement then embed a 20 x 20 weave white glass reinforcing cloth between two 1/16 inch coats of Benjamin Foster 30-36. The glass cloth and second coat shall overlap adjacent covering by two inches. Insulation shall be fiberglass pipe wrap as manufactured by Owens-Corning, Johns Mansfield, or equal.

C. The insulation shall be covered with a smooth, weatherproof, embossed aluminum jacket with integral Kraft-polyethylene vapor barrier separating the insulation from the metal. The factory applied aluminum jackets shall be at least 0.016 inches thick for interior installation and at least 0.031 inches thick for exterior installation. They shall be at least 36" long as measured along the pipe.

D. Circumferencially, the width of the sheets shall be 1/2" to 2" greater than the circumference of the pipe insulation, with a Pittsburgh locktype on the longitudinal edge.

E. The metal jackets shall be held in place by 0.020" thick, 3/4 inch wide, metal bands on 9" centers.

F. Special care shall be taken to make all exterior insulation jackets completely waterproof by the use of an appropriate silicone base sealant at all joints, etc.

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PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 15390

SCHEDULES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Reference Section 15000, Basic Mechanical Requirements.

1.02 PIPING SYSTEM SCHEDULES

A. Piping requirements for this Section are outlined on the Drawings, and in the Piping System Schedule. In the absence of a specified test pressure, pipe shall be tested at a pressure 50 percent greater than the normal operating pressure as determined by the Engineer or 10 psig, whichever is greater unless the Schedule indicates that no test is required.

B. If the pipe material is not shown on the Piping System Schedule or otherwise specified, the following materials shall be used:

Pipe Size	Material	Type of Joint	Class/Design	Test Pressure
4-in and larger	DIP	Flanged (Exposed)	Class 53	(1)
		Restrained (Buried)	Pressure Class 350	
Less than 4-in	PVC	Socket	Sch 80	(1)

(1) Test at 150 percent of normal operating pressure or 10 psi, whichever is greater.

1.03 VALVE SCHEDULES

A. Performance Affidavits shall be required for all valves listed in the valve schedule(s). Performance Affidavits shall be provided in accordance with Section 11000, Equipment General Provisions and Section 01300, Submittals. All valves shall be tagged by the manufacturer according to the control valve designations listed in the Schedule.

B. Valves not listed in the valve schedule(s) shall be manually operated, unless otherwise shown on the Drawings.

1.04 GATE SCHEDULES

A. Performance Affidavits shall be required for all gates listed in the following schedule(s). Performance Affidavits shall be provided in accordance with Section 11000, Equipment General Provisions and Section 01300, Submittals. Gates shall be tagged by the manufacturer according to locations listed in the Schedule.

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PIPING SYSTEM SCHEDULE

PIPING SYSTEM SCHEDULE					
PIPE DESIGNATION	MATERIAL	TYPE OF JOINT	CLASS/DESIGN	RESTRAINT SYSTEM DESIGN (1) PRESSURE	TEST PRESSURE
A	STAINLESS STEEL	WELDED/FLANGED	SEE SECTION 15013, STEEL PIPE FOR LOW PRESSURE PROCESS AIR SERVICE	25 PSI	25 PSI
ML	DIP	RESTRAINED (BURIED) FLANGED (EXPOSED)	PRESSURE CLASS 350 CLASS 53	60 PSI	30 PSI
NPW	<4" CPVC (EXPOSED)[2]	SOCKET	SCH 80	225 PSI	115 PSI
	< 4" PVC (BURIED)	SOCKET	SCH 80		
	> = 4" DIP	RESTRAINED	PRESSURE CLASS 350		
PW	<4" CPVC (EXPOSED)[2]	SOCKET	SCH 80	250 PSI	150 PSI
	< 4" PVC (BURIED)	SOCKET	SCH 80		
	< 4" COPPER	SOLDERED	TYPE K (BURIED) TYPE L (EXPOSED)		
	> = 4" DIP	RESTRAINED	PRESSURE CLASS 350		
RAS	DIP	RESTRAINED	PRESSURE CLASS 250	75 PSI	40 PSI
	PCCP	RESTRAINED	WORKING = 25 PSI SURGE = 50 PSI TOTAL = 75 PSI		
SS	DIP	PUSH-ON	PRESSURE CLASS 350	SEE SPEC SECTION 2H	SEE SPEC SECTION 2H
	RCP	PUSH-ON	CLASS IV		
CASING PIPE FOR PW & NPW	PVC	SOCKET	SCH 40	NA	NA

(1) DESIGN PRESSURE SHALL BE USED TO DETERMINE THE SIZE, NUMBER, MATERIAL AND DIMENSIONS OF TABS AND THREADED-RODS FOR PIPING SPECIFIED OR SHOWN TO HAVE THREADED-RODS FOR THRUST RESTRAINT.

(2) PROVIDE HEAT TRACING AND INSULATION AS SPECIFIED IN SECTION 15391 ON ALL EXTERIOR **EXPOSED** PIPING INDICATED.

PIPING SYSTEM DESIGNATIONS

A	PROCESS AIR	PW	POTABLE WATER
ML	MIXED LIQUOR	RAS	RETURN ACTIVIATED SLUDGE
NPW	NON POTABLE WATER	SS	SANITARY SEWER

ELECTRICALLY OPERATED VALVE SCHEDULE								
TAG NO.	VALVE TYPE	OPERATOR TYPE	SIZE (in)	FLOW	MAX DIFFERENTIAL PRESSURE (psi)	CLASS	SERVICE	LOCATION
MOV-1110	BUTTERFLY	MODULATING[1]	16	7,400 SCFM	10	150	AIR	BLOWER 1 INLET
MOV-1210	BUTTERFLY	MODULATING[1]	16	7,400 SCFM	10	150	AIR	BLOWER 2 INLET
MOV-1310	BUTTERFLY	MODULATING[1]	20	11,100 SCFM	10	150	AIR	BLOWER 3 INLET
MOV-1410	BUTTERFLY	MODULATING[1]	20	11,100 SCFM	10	150	AIR	BLOWER 4 INLET
MOV-2121	BUTTERFLY	MODULATING[1]	16	8,000 SCFM	10	150	AIR	AERATION TANK 1 – ZONE 1
MOV-2122	BUTTERFLY	MODULATING[1]	16	8,000 SCFM	10	150	AIR	AERATION TANK 1 – ZONE 2
MOV-2221	BUTTERFLY	MODULATING[1]	20	12,000 SCFM	10	150	AIR	AERATION TANK 2 – ZONE 1
MOV-2222	BUTTERFLY	MODULATING[1]	20	12,000 SCFM	10	150	AIR	AERATION TANK 2 – ZONE 2

[1] 4-20 mA CONTROL – SEE SPECIFICATIONS 15100 AND 17950
[2] PROVIDE REMOTE CONTROL STATION AS SPECIFED IN SECTION 15100

SLIDE GATE SCHEDULE							
TAG NO.	DESCRIPTION	SIZE		DESIGN HEAD[1] (ft.)	DISTANCE FROM CHANNEL INVERT TO OPERATING FLOOR (ft.)	OPERATOR TYPE	STAND TYPE
		WIDTH (ft.)	HEIGHT (ft.)				
MOG-2610	FINAL CLARIFIER DISTRIBUTION GATE NO. 1	4	4	4	3.5[2]	ELECTRIC	SELF-CONTAINED
MOG-2620	FINAL CLARIFIER DISTRIBUTION GATE NO. 2	4	4	4	3.5[2]	ELECTRIC	SELF-CONTAINED
MOG-2630	FINAL CLARIFIER DISTRIBUTION GATE NO. 3	4	4	4	3.5[2]	ELECTRIC	SELF-CONTAINED
MOG-2640	FINAL CLARIFIER DISTRIBUTION GATE NO. 4	4	4	4	3.5[2]	ELECTRIC	SELF-CONTAINED

[1] Maximum Design Head is for both seating and unseating head condition as measured from gate invert to the maximum differential water surface elevation. Maximum Design Head is the depth of water on one side with no water on other side.

[2] Downward opening gate. Distance is from minimum open elevation to operating level.

SLUICE GATE SCHEDULE								
TAG NO.	DESCRIPTION	SIZE			DESIGN HEAD* (ft)	WALL THIMBLE TYPE	OPERATOR	STAND
		WIDTH (in)	HEIGHT (in)	DIAMETER (in)				
MOG-2510	JUNCTION STRUCTURE BYPASS[2]	12	24	-	10	F	ELECTRIC	FLOORSTAND
MOG-2520	JUNCTION STRUCTURE BYPASS[2]	12	24	-	10	F	ELECTRIC	FLOORSTAND

[1] Maximum Design Head is for both seating and unseating head condition as measured from gate centerline to the maximum differential water surface elevation for sluice gates.

[2] Self-contained sluice gates

- END OF SECTION -

SECTION 16000

BASIC ELECTRICAL REQUIREMENTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.

B. Reference Section 17000, Control and Information System Scope and General Requirements for scope of work details as they relate to the Division 17 Subcontractor.

C. The electrical scope of work for this project primarily includes, but is not limited to, the following:

1. Furnish and install new 27kV class medium voltage vacuum circuit breaker switchgear within a prefabricated metal building.

2. Furnish and install new standby diesel engine generator system within prefabricated metal enclosure.

3. Furnish and install new medium voltage liquid-filled, pad-mount style, step up and step down transformers.

4. Furnish and install low voltage molded case circuit breaker switchboards and other equipment within a prefabricated metal blower electrical building.

5. Furnish and install low voltage motor control equipment including reduced voltage motor starters.

6. Furnish and install power panelboards, lighting panelboards, dry-type transformers, and other low voltage electrical power distribution equipment.

7. Furnish and install all aboveground raceway systems including conduit, fittings, boxes, supports, and other pertinent components.

8. Furnish and install all underground raceway systems including conduit, fittings, manholes, handholes and other pertinent components.

9. Furnish and install new medium voltage wire and cable to replace existing 35kV class power distribution loop for facility.

10. Furnish and install all low and medium voltage wire and cable resulting in a complete and operable electrical system.

11. Furnish and install new lighting systems and wiring devices.

12. Other electrical work as specified herein and indicated on the Drawings.

D. All material and equipment must be the product of an established, reputable, and approved manufacturer; must be new and of first class construction; must be designed and guaranteed to perform the service required; and must bear the label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the Engineer.

E. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner.

F. Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer. The Contractor's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.

G. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.

H. All electrical components and systems, including electrical equipment foundations, shall be designed to resist operational forces as well as lateral sway and axial motion from seismic and thermal forces. Seismic support design shall be in accordance with Section 01350 – Seismic Anchorage and Bracing.

1.02 EQUIPMENT LOCATION

A. The Drawings show the general location of feeders, transformers, outlets, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The Contractor shall carefully investigate the structural and finish conditions affecting all of his work and shall arrange such work accordingly; furnishing such fittings, junction boxes, and accessories as may be required to meet such conditions. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to ensure that proposed equipment will fit properly in spaces indicated.

B. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The Contractor shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings.

1.03 LOCAL CONDITIONS

A. The Contractor shall examine the site and become familiar with conditions affecting the work. The Contractor shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.

B. In addition, the Contractor shall relocate all duct banks, lighting fixtures, receptacles, switches, boxes, and other electrical equipment as necessary to facilitate the Work included in this project. Costs for such work shall be included in the Bid.

C. The Contractor is responsible for coordinating all electric utility equipment installations with the serving electric utility. The Contractor shall furnish and install all electric utility equipment required by the electric utility to be installed by the Contractor whether specifically shown on the Drawings or not.

D. The Contractor shall furnish and install the following electrical equipment in association with the electrical utility as a minimum:

1. Service entrance, direct buried conduit and wire, as indicated on the Drawings and as directed by the Utility. New service shall be routed in accordance with the SCE&G transmission department permit, as this route passes beneath high voltage lines.

2. Terminations at the Utility's connection cabinet which will be at the base of the new utility pole.

3. Contractor is responsible for coordination between contractor-installed conduits and new utility connection box to ensure contractor's raceway is installed below box, in the correct location.

E. The electric utility will furnish and install the following equipment to prepare for the new electrical service:

1. New utility pole for new service adjacent to existing pole.

2. Metering equipment cabinets and/or bases.

3. New 27kV connection box to provide means for Contractor-supplied cables to connect to utility at/near grade.

4. Conduit and wire required from metering cabinet to metering current transformers and potential transformers.

F. The Contractor is responsible for ensuring all electric utility equipment and construction installed by the Contractor is furnished and installed in accordance with the electric utility's design specifications and requirements. The Contractor is fully responsible for coordinating his scope of work with the electric utility. Any additional required electric utility construction or equipment not specified herein or shown on the Drawings shall be supplied by the Contractor at no additional cost to the Owner.

G. The contact person at the serving electrical utility (SCE&G) is:

Joel Knight, PE
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1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, Section 01300, Submittals and the requirements of the individual specification sections, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts List

4. Proposed Testing Methods and Reports of Certified Shop Tests.

5. Reports of Certified Field Tests.

6. Manufacturer's Representative's Certification.

B. Submittals shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements.

C. Submittals will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which the Contractor has provided no information.

D. Some individual Division 16 specification sections may require a Compliance, Deviations, and Exceptions (CD&E) letter to be submitted. If the CD&E letter is required and shop drawings are submitted without the letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a

letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

E. Seismic support design for all nonstructural electrical components (conduit, raceways, freestanding equipment, etc.) shall be in accordance with all applicable federal, state and local building code requirements and Section 01350 – Seismic Anchorage and Bracing.

1.05 APPLICABLE CODES AND REQUIREMENTS

A. Conformance

1. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the following:

   a. Insurance Rating Organization having jurisdiction
   b. The serving electrical utility company
   c. The currently adopted edition of the National Electrical Code (NEC)
   d. The National Electric Manufacturers Association (NEMA)
   e. The Institute of Electrical and Electronic Engineers (IEEE)
   f. The Insulated Cable Engineers Association (ICEA)
   g. The American Society of Testing Materials (ASTM)
   h. The American National Standards Institute (ANSI)
   i. The requirements of the Occupational Safety Hazards Act (OSHA)
   j. The National Electrical Contractors Association (NECA) Standard of Installation
   k. National Fire Protection Association (NFPA)
   l. International Electrical Testing Association (NETA)
   m. All other applicable Federal, State and local laws and/or ordinances.

2. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.

B. Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid. Ignorance of any rule, requirement, or Specification shall not be allowed as an excuse for nonconformity. Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors which may exist in the drawings submitted or in the satisfactory operation of any equipment.

C. Certification

1. Upon completion of the work, the Contractor shall obtain certificate(s) of inspection and approval from the National Board of Fire Underwriters or similar inspection organization having jurisdiction and shall deliver same to the Engineer and the Owner.

1.06 PERMITS AND INSPECTIONS

A. The Contractor shall reference the General Conditions and Section 01010, Summary of Work.

1.07 TEMPORARY LIGHTING AND POWER

A. The Contractor shall reference the General Conditions and Section 01510, Temporary Utilities.

1.08 TESTS

A. Upon completion of the installation, the Contractor shall perform tests for operation, load (Phase) balance, overloads, and short circuits. Tests shall be made with and to the satisfaction of the Owner and Engineer.

B. The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Owner. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five (5) times.

C. Refer to each individual specification section for detailed test requirements.

D. The Contractor shall complete the installation and field testing of the electrical installation **at least two (2) weeks** prior to the start-up and testing of all other equipment. During the period between the completion of electrical installation and the start-up and testing of all other equipment, the Contractor shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.

E. Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, manpower and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any of his equipment required as part of the field tests of other systems.

1.09 INFRARED INSPECTION

A. Just prior to the final acceptance of a piece of equipment, the Contractor shall perform an infrared inspection to locate and correct all heating problems associated with electrical equipment terminations.

B. The infrared inspection shall apply to all new equipment and existing equipment that is in any way modified under this Contract. All heating problems detected with new equipment furnished and installed under the Scope of this Contract shall be corrected by the Contractor. All problems detected with portions of existing equipment modified under this Contract shall also be corrected by the Contractor.

C. Any issues detected with portions of existing equipment that were not modified under this Contract are not the responsibility of the Contractor. Despite the Contractor not being held responsible for these problems, the Contractor shall report them to the Owner and Engineer immediately for resolution.

D. The infrared inspection report shall include both digital and IR pictures positioned side by side. Both the digital and IR pictures shall be clear and high quality. Fuzzy, grainy, or poorly illuminated pictures are not acceptable. The IR picture shall be provided with a temperature scale beside it, and an indication of the hot spot temperature in each picture. Reports shall be furnished in a 3-ring binder, with all pages printed in full color, with equipment assemblies separated by tabs.

1.10 PROTECTIVE DEVICE SETTING AND TESTING

A. The Contractor shall provide the services of a **qualified, independent, third party testing company** using N.E.T.A. certified technicians to adjust, set, calibrate and test all protective devices in the electrical system. The company shall not be a subsidiary of the electrical equipment manufacturer. The qualifications of the testing company and resumes of the technicians as well as all data forms to be used for the field testing shall be submitted.

B. All protective devices in the electrical equipment shall be set, adjusted, calibrated and tested in accordance with the manufacturers' recommendations, the coordination study, and best industry practice.

C. Proper operation of all equipment associated with the device under test and its compartment shall be verified, as well as complete resistance, continuity and polarity tests of power, protective and metering circuits. Any minor adjustments, repairs and/or lubrication necessary to achieve proper operation shall be considered part of this Contract.

D. All solid state trip devices shall be checked and tested for setting and operation using manufacturers recommended test devices and procedures.

E. Circuit breakers and/or contactors associated with the above devices shall be tested for trip and close functions with their protective device.

F. When completed, the Contractor shall provide a comprehensive report for all equipment tested indicating condition, readings, faults and/or deficiencies in same. Inoperative or defective equipment shall be brought immediately to the attention of the Engineer.

G. Prior to placing any equipment in service, correct operation of all protective devices associated with this equipment shall be demonstrated by field testing under simulated load conditions.

1.11 POWER SYSTEM STUDIES

A. The Contractor shall provide power systems studies performed by a registered professional engineer in accordance with Section 16055 – Power System Studies.

1.12 SCHEDULES AND FACILITY OPERATIONS

A. Since the equipment testing required herein shall require that certain pieces of equipment be taken out of service, all testing procedures and schedules must be submitted to the Engineer for review and approval one (1) month prior to any work beginning. When testing has been scheduled, the Engineer must be notified 48 hours prior to any work to allow time for load switching and/or alternation of equipment. In addition, all testing that requires temporary shutdown of facility equipment must be coordinated with the Owner/Engineer so as not to affect proper facility operations.

B. At the end of the workday, all equipment shall be back in place and ready for immediate use should a facility emergency arise. In addition, should an emergency condition occur during testing, at the request of the Owner, the equipment shall be placed back in service immediately and turned over to Owner personnel.

C. In the event of accidental shutdown of Owner equipment, the Contractor shall notify Owner personnel immediately to allow for an orderly restart of affected equipment.

D. Maintaining the operation of these facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01520 of the Specifications for construction sequencing and specific operational constraint information.

1.13 MATERIALS HANDLING

A. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material will be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer. If space heaters are provided in a piece of electrical equipment, they shall be temporarily connected to a power source during storage. The Contractor shall store equipment and materials in accordance with Section 01550, Site Access and Storage.

1.14 WARRANTIES

A. Unless otherwise specified in an individual specification section, all equipment and electrical construction materials furnished and installed under Division 16 shall be provided with a warranty in accordance with the requirements of Section 11000, Equipment General Provisions and the General Conditions.

1.15 TRAINING

A. Unless otherwise specified in an individual specification section, all training for equipment furnished and installed under Division 16 shall be provided in accordance with the requirements of Section 11000, Equipment General Provisions.

PART 2 -- PRODUCTS

2.01 PRODUCT REQUIREMENTS

A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.

C. All equipment and materials shall be new, unless indicated or specified otherwise.

D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that are provided under this Contract meet the requirements of Underwriters Laboratories, Inc., in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming to this requirement.

2.02 SUBSTITUTIONS

A. Unless specifically noted otherwise, any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contractor, in such cases may, at his option use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

2.03 CONCRETE

A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A unless otherwise specified. Concrete and reinforcing steel shall meet the appropriate requirements of Division 3 of the Specifications.

B. The Contractor shall provide concrete equipment pads for all free standing electrical apparatus and equipment located on new or existing floors or slabs. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings and shall conform to standard detail for equipment pads shown on the Contract Drawings. Equipment pads shall not have more than 3” excess concrete beyond the edges of the equipment.

C. The Contractor shall provide concrete foundations for all free standing electrical apparatus and equipment located outdoors or where floors or slabs do not exist and/or are not or provided by others under this Contract. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required. The location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of the foundations. Equipment foundations shall be constructed as detailed on the Drawings or if not detailed on the Drawings shall be 6 inches thick minimum reinforced with #4 bars at 12-inch centers each way placed mid-depth. Concrete shall extend 6 inches minimum beyond the extreme of the equipment base and be placed on a compacted stone bed (#57 stone or ABC) 6 inches thick minimum.

2.04 RUBBER INSULATING MATTING

A. Rubber insulating matting shall be furnished and installed on the floor and in front of each piece of electrical equipment that is located indoors and installed under this Contract. Rubber insulating matting shall not be installed outdoors. The mat shall be long enough to cover the full length of the equipment. The mat shall be 1/4 inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The matting shall meet OSHA requirements and the requirements of ASTM D-178 for Type 2, Class 2 insulating matting. Matting shall be 36 inches wide, minimum. However, matting width shall be no less than the NEC working clearance for the equipment with which it is associated.

B. Matting shall be provided for the following equipment:

- PLC Enclosures
- Motor Control Centers
- Switchgear Assemblies
- Switchboard Assemblies
- Reduced Voltage Starters
- Panelboards
- Manual Transfer Switches
- Generator Output Circuit Breakers
- Generator Control Panels

PART 3 -- EXECUTION

3.01 CUTTING AND PATCHING

A. Coordination

1. The Work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

B. Damage

1. The Contractor shall perform all chasing, channeling, drilling and patching necessary to the proper execution of his Contract. Any damage to the building, structure, or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at his own expense.

C. Existing Equipment

1. Provide a suitable cover or plug for openings created in existing equipment as the result of work under this Contract. For example, provide round plugs in equipment enclosures where the removal of a conduit creates a hole and the enclosure. Covers and plugs shall maintain the NEMA rating of the equipment enclosure. Covers and plugs shall be watertight when installed in equipment located outdoors.

3.02 EXCAVATION AND BACKFILLING

A. The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable requirements of Division 2.

3.03 CORROSION PROTECTION

A. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

- END OF SECTION -

SECTION 16055

POWER SYSTEM STUDIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall provide Short Circuit Studies, Equipment Evaluation Studies, Protective Device Coordination Studies, Load Flow Analyses, and Arc Flash Risk Assessment performed by a professional electrical engineer currently registered in the State of South Carolina.

B. The scope of work for these studies shall include the **entire** Lower Berkeley WWTP. All existing and proposed electrical equipment and distribution systems at the facility shall be included in the studies, although not all electrical equipment is shown on the Contract Drawings for this particular project. As-built documentation will be furnished by the Owner after the bid opening to facilitate completion of the studies.

C. Prior to receiving final approval of the distribution equipment shop drawings for the equipment proposed under this Contract and/or prior to release of that equipment for manufacture, the Preliminary Study Report, as specified herein, shall be submitted and approved. Contractor shall expedite the completion of the Preliminary Study Report so that final approval of proposed equipment is not delayed.

1.02 REFERENCE CODES AND STANDARDS

A. Institute of Electrical and Electronic Engineers (IEEE):

1. Standard 141, Recommended Practice for Electrical Power Distribution for Industrial Plants

2. Standard 241, Recommended Practice for Electrical Power Systems in Commercial Buildings

3. Standard 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Systems

4. Standard 399, Recommended Practice for Industrial and Commercial Power System Analysis

5. Standard 519-1992, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

6. Standard 1584-2002/2004a, IEEE Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

1. Standard C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

2. Standard C37.91, Guide for Protective Relay Applications to Power Transformers

3. Standard C37.95, Guide for Protective Relaying of Utility-Consumer Interconnections.

4. Standard C37.96, Guide for AC Motor Protection

5. Standard C57.12.59, Guide Dry-Type Transformer Through-Fault Current Duration

6. Standard C.57.13, Standard Requirements for Instrumentation Transformers

7. Standard C57.109, Guide for Liquid-Immersed Transformer Through Fault-Current Duration

C. National Electrical Code (NEC)

D. National Fire Protection Agency (NFPA):

1. NFPA 70E, Standard for Electrical Safety in the Workplace (2018 edition)

1.03 SUBMITTALS

A. The Contractor shall submit for review and approval, four (4) paper copies of the Preliminary Power System Studies Report, four (4) paper copies of the Pre-final Power System Studies Report, and six (6) paper copies of the Final Power System Studies Report. One (1) electronic copy of each report shall be also submitted on a CD. The electronic version of each report shall be in the PDF file format. Each section of the report shall be placed in a separate PDF file to allow fast and easy navigation between sections. Additional details regarding the report requirements are specified elsewhere herein.

B. All Reports shall bear the signature and seal of the professional electrical engineer that performed the study.

C. The Contractor shall also submit one (1) electronic copy of the system model and all required database files generated by the software analysis package used. Files shall be placed on a CD and submitted with the Preliminary, Pre-final, and Final Power System Studies Reports.

1.04 QUALIFICATIONS

A. The Power System Studies shall be performed by a professional electrical engineer registered in the State of South Carolina. The registered professional electrical engineer shall have a minimum of five (5) years of experience in performing power systems studies.

B. The resume of the registered professional electrical engineer shall be submitted for approval prior to the start of work. An experience table shall also be provided detailing the power systems studies of similar scope to this Contract that have been performed by the proposed engineer over the last two (2) years. The table shall, at a minimum, list the facility owner's name, facility contact person with phone number and email address, and overall scope of work that was provided.

PART 2 -- PRODUCTS

2.01 POWER SYSTEM STUDIES

A. General

1. The Contractor shall provide Short Circuit Studies, Equipment Evaluation Studies, Protective Device Coordination Studies, Load Flow Analyses, and Arc Flash Risk Assessment for the entire electrical system. The studies shall be performed in accordance with IEEE 399, Recommended Practice for Industrial and Commercial System Power Analysis (IEEE Brown Book).

2. The studies shall include all portions of the electrical distribution system from the serving electric utility company protective devices, the normal and standby power sources down to and including the 208 volt equipment. The studies shall include all low voltage switchgear, motor control centers (MCCs), Variable Frequency Drives (VFDs) and panelboards as shown on the Drawings. System connections and those which result in maximum fault conditions shall be adequately covered in the study.

3. The studies shall be performed with the aid of SKM Systems Analysis Power Tools for Windows (PTW) software, Version 8.0 or newer. No other software analysis packages are acceptable.

B. Data Collection for the Studies

1. The Contractor shall collect all required utility transformer and service information for use in these studies. The serving electric utility representative contact information can be found in Section 16000, Basic Electrical Requirements.

2. One (1) field visit to the project site to collect pertinent data from existing equipment by the personnel performing the studies is permitted. The visit shall span as many days as required to collect all necessary information. This visit shall occur as soon after the Contract is awarded as possible and shall be coordinated with the Owner. The Contractor and personnel performing these studies are responsible for collecting all required data for these studies.

C. Short Circuit Studies

1. The short circuit study shall be performed in accordance with the latest editions of IEEE Std. 399 and IEEE Std. 141.

2. The study input data shall include the serving electric utility company's short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances.

3. Short circuit close and latch duty values and interrupting duty values shall be calculated on the basis of assumed three-phase bolted short circuits at each bus, low voltage switchgear, low voltage motor control center, distribution panelboard, pertinent branch circuit panel and other significant locations through the system. The short circuit tabulations shall include symmetrical fault currents, and X/R ratios. For each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, shall be listed with its respective X/R ratio.

4. The short circuit study report shall include recommendations for equipment selection based on calculated short circuit values and all input and output data from the software model.

D. Equipment Evaluation Studies

1. An equipment evaluation study shall be performed to determine the adequacy of both existing and proposed circuit breakers, panelboards, motor control centers, automatic transfer switches, busses, etc. located at the plant by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied. A table shall be provided in the report showing the calculated fault currents and the corresponding short circuit ratings of the existing equipment.

E. Protective Device Coordination Studies

1. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage circuit breaker trip characteristics and settings.

2. The coordination study shall include all low voltage classes of equipment from the serving electric utility company service protective devices down to and including all adjustable circuit protective devices. The phase and ground overcurrent protection shall be included as well as settings of all other adjustable protective devices.

3. The time-current characteristics of the proposed protective devices shall be printed on a log-log scale. The plots shall include complete titles, representative one-line diagram and legends, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves and fuses. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits and significant symmetrical and asymmetrical fault currents. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic

curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.

4. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and connections, manufacturer and type, range of adjustment and recommended settings.

F. Load Flow Analyses

1. A load-flow analysis shall be performed to determine the steady-state loading profile of the plant. The analysis shall be based on both the serving electric utility as a source and the standby generator as a source. From the results of the load flow analysis, the report shall indicate areas of overloaded conductors or equipment in the power distribution system design.

2. The report shall also include a total source load summary table, as well as single line diagrams showing only the load flow data.

3. Load flow analysis results shall also be presented in a tabular format in the report.

G. Arc Flash Risk Assessment

1. An Arc Flash Risk Assessment shall be performed in accordance with IEEE Std. 1584, NFPA 70E, and OSHA 29-CFR, Part 1910 Subpart S.

2. The Arc Flash Risk Assessment Report shall include but not be limited to the following:

a. An executive summary outlining the electrical distribution system

b. A brief overview of what arc flash hazards are and how to avoid them.

c. Serving electric utility information received. Copies of the information received shall be included in an appendix.

d. All assumptions made to complete the report

e. Definitions of key terms used in the report

f. Any recommendations to reduce the arc flash incident energies where they are found to exceed 12cal/cm^2.

g. A PPE table that defines the Personnel Protective Equipment (PPE) classes and clothing descriptions identified in the report and labels.

h. Arc flash hazard warning labels as specified herein.

i. An NFPA 70E energized work permit for each location where a warning label is provided.

j. Arc flash evaluation summary sheets as specified herein

k. Separate set of single line diagrams that show incident energies, and protective device settings. Only pertinent arc flash hazard data shall be displayed on these single line diagrams. Data from all other study calculations shall not be shown.

3. The following parameters shall be used in the Arc Flash Hazard Study:

a. Working distance for all equipment: 18”

b. Maximum arc duration for all equipment: 2 seconds

c. Incident energies, arc flash hazard boundaries shall be calculated over a +/- 15% of calculated arcing fault current. The worst case incident energies that result shall be used in the study report.

d. The equipment that connects to both the electric utility service and the standby power is in a closed-transition configuration. The power sources will be capable of paralleling with each other.

e. The arc flash analysis shall be performed as if the facility is being supplied by either of the electric utilities **and** as if the facility is being supplied by the standby generators. The worst case values from each calculation shall be used in the study report.

4. Arc Flash Warning Labels shall be produced for each location that allows access to energized parts. Labels shall be printed in color on adhesive backed labels. Labels shall be an ANSI Z535.4 compliant (minimum size 4 in. x 6 in.) thermal transfer type label. For incident energy values of less than 40 cal/cm^2, the labels shall have an orange colored header with the word “WARNING”. For incident energy values equal to and above 40 cal/cm^2, the labels shall have a red colored header with the word “DANGER”. Each label shall include the following information:

a. Bus name

b. System operating voltage

c. Date of issue

d. Flash hazard protection boundary

e. Limited approach boundary

f. Restricted boundary

g. Prohibited boundary

h. Incident energy level

5. Arc Flash Evaluation Summary Sheets shall be produced. All values shown on the Summary Sheets shall be commensurate with the values shown on the single line diagrams. Summary sheets shall list the following:

   a. Bus name

   b. Upstream protective device name and protective device settings

   c. Bus line-to-line voltage

   d. Bus bolted fault

   e. Protective device bolted fault current

   f. Arcing fault current

   g. Protective device trip / delay time

   h. Breaker opening time

   i. Solidly grounded column

   j. Equipment type

   k. Gap

   l. Arc flash boundary

   m. Working distance

   n. Incident energy

2.02 Study Reports

A. The results of the Power Systems Studies shall be summarized in a series of reports. A total of three (3) separate reports shall be provided as follows:

   1. Preliminary Report – The Preliminary Report shall consist of all power systems studies as specified herein, with the following exceptions:

      a. NFPA 70E energized work permits shall not be included

      b Arc flash hazard warning labels shall be printed on plain paper for **format review purposes only**. Actual labels with calculated values shall not be included.

   2. Pre-final Report – The Pre-final Report shall incorporate all comments received from the previous report review and shall include specific equipment data from the approved shop drawings of the proposed electrical equipment. The Pre-final Report shall consist of all power systems studies as specified herein, with the following exceptions:

a. NFPA 70E energized work permits shall not be included

b. Sample arc flash hazard warning labels shall be printed on plain paper for **calculated value review purposes**. Actual adhesive labels shall not be included.

3. Final Report – The Final Report shall consist of all power systems studies as specified herein, including final adhesive arc flash hazard warning labels. Final report shall incorporate all installed electrical equipment, including any field changes made during construction, and all comments received from the previous report review. All 'as-left' protective device settings shall be included in the report.

B. Reports shall be furnished in the quantities specified herein, neatly organized into properly identified 3" (minimum) 3-ring binders. Tabs shall clearly separate each section of the report. Each report shall begin with a table of contents. The following sections shall be included in the report as a minimum:

1. Executive Summary

2. Short Circuit Study

3. Equipment Evaluations

4. Protective Device Coordination Study

5 Load Flow Analysis

6. Arc Flash Study

C. All data used in the reports such as conductor sizes and lengths, motor sizes, utility contribution information, and the like shall be included in the appendices of the report.

D. All single line diagrams and time current curves shall be provided in the reports on 11x17 paper, properly folded to fit into the report binder. Use of standard 8.5x11 paper for these purposes is not permitted. Single line diagrams shall be appropriately split up between several sheets (if required) to allow the drawing scale to be adjusted in order to make text and symbols legible.

PART 3 – EXECUTION

3.01 FIELD ADJUSTMENT

A. Contractor shall adjust all relay and protective device settings according to the recommended settings table provided in the **approved** Pre-Final Report.

B. Contractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

3.02 ARC FLASH LABELS

A Contractor shall place approved adhesive arc flash labels on equipment after the Final Report is reviewed and approved.

3.03 TRAINING

A. The Contractor shall train the Owner's qualified electrical personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET) or equivalent.

- END OF SECTION -

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SECTION 16111

CONDUIT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install conduits and conduit fittings to complete the installation of all electrically operated equipment as specified herein, indicated on the Drawings, and as required.

B. Requirements for conduit clamps, support systems, and anchoring are not included in this Section. Reference Section 16190, Electrical Supporting Devices, for these requirements.

C. Reference Section 16000, Basic Electrical Requirements.

1.02 CODES AND STANDARDS

A. Conduits and conduit fittings shall be designed, manufactured, and/or listed to the following standards as applicable:

1. American National Standards Institute (ANSI)

a. ANSI B1.20.1 – Pipe Threads, General Purpose

b. ANSI C80.3 – Steel Electrical Metallic Tubing

c. ANSI C80.5 – Electrical Rigid Aluminum Conduit

d. ANSI FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable

2. Underwriters Laboratories (UL)

a. UL 1 – Standard for Flexible Metal Conduit

b. UL 6A – Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel

c. UL 360 – Standard for Liquid-tight Flexible Metal Conduit

d. UL 467 – Grounding and Bonding Equipment

e. UL 514B – Conduit, Tubing, and Cable Fittings

f. UL 651 – Standard for Schedule 40 and 80 Conduit and Fittings

g. UL 797 – Electrical Metallic Tubing-Steel

h. UL 1203 - Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations

i. UL 1479 – Standard for Fire Tests of Penetration Fire Stops

j. UL 1660 – Liquid-tight Flexible Nonmetallic Conduit

3. National Electrical Manufacturer's Association (NEMA)

a. NEMA RN 1 – PVC Externally Coated Rigid Aluminum Conduit

b. NEMA TC-2 – Electrical PVC Conduit

c. NEMA TC-3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing

B. Others

1. ACI-318 – Building Code Requirements for Structural Concrete

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300 – Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets for conduits and fittings.

2. Conduit identification methods and materials.

3. Evidence of training for all personnel that will install PVC coated rigid metal conduit.

1.05 DEFINITIONS

A. Conduits are categorized by the circuit type of the wiring to be installed inside. Conduits are defined as follows:

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1. Power Conduits – Conduits that carry AC or DC power wiring from a source to a load. Conduits that carry lighting and receptacle wiring.

2. Control Conduits – Conduits that carry AC or DC discrete control wiring between devices and/or equipment. Conduits that carry fiber optic cables between devices and/or equipment.

3. Instrumentation Conduits – Conduits that carry AC or DC analog signal wiring between devices and/or equipment.

B. Conduit categories are indicated on the Drawings by the leading letter of the conduit tag. Conduit tag leading letters are defined as follows:

1. P – Power Conduit

2. C – Control Conduit

3. I – Instrumentation Conduit

PART 2 – PRODUCTS

2.01 GENERAL

A. Conduit and conduit fitting products are specified in the text that follows this article. Reference Part 3 herein for the application, uses and installation requirements of these conduits and conduit fittings.

B. All metallic conduit fittings shall be UL 514B and UL 467 Listed, and constructed in accordance with ANSI FB 1. All metallic conduit fittings for use in Class I Division I hazardous areas shall be UL 1203 Listed. All non-metallic fittings shall be UL 651 Listed and constructed in accordance with NEMA TC-3.

C. Flexible conduit couplings for use in Class I Division I hazardous areas shall have threaded stainless steel end fittings and a flexible braided core. Flexible braid shall be constructed of stainless steel where available in the conduit trade size required for the application. Where stainless steel braid is not available, the braid shall be provided with a PVC coating. No other braid types or materials are acceptable.

D. Where threading is specified herein for conduit fitting connections, the fittings shall be manufactured to accept conduit that is threaded to ANSI B1.20.1 requirements.

E. Conduit expansion fittings for all conduit materials of construction shall be capable of 4 inches of movement along the axis of the conduit for trade sizes 2 inches or less. Expansion fittings shall be capable of 8 inches of movement along the axis of the conduit for trade sizes greater than 2 inches.

F. Conduit deflection fittings for all conduit materials of construction shall be provided with a flexible neoprene outer jacket that permits up to ¾ inch of expansion/contraction along the axis of the conduit as well as up to ¾ inch of parallel misalignment between the conduit axes. Outer jacket shall be secured to the conduit hubs by stainless steel clamps.

G. Conduit seals shall either be Listed and labeled for 40% fill, or conduit reducing fittings and a trade size larger conduit seal shall be provided to achieve 25% or less fill within the seal. Percentage fill calculation shall be based on the conductors to be installed. Conduit seals shall be provided with breathers and/or drains where required by the NEC.

H. Conduit insulating bushings shall be constructed of plastic and shall have internal threading.

I. Additional conduit and conduit fitting requirements are specified in the articles that follow based on the specific conduit material of construction to be used.

2.02 RIGID NONMETALLIC CONDUIT AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be Schedule 40 or 80 (dependent on application) polyvinyl chloride (PVC) construction, manufactured in accordance with NEMA TC-2, UL 651 Listed, and suitable for conductors with 90 degree C insulation.

B. Conduit Bodies for use with Rigid Nonmetallic Conduit

1. Conduit bodies shall be constructed of PVC. Conduit hubs shall be integral to the conduit body and shall be smooth inside to accept a glued conduit connection.

2. Conduit body shall be provided with cover that is affixed in place by stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

C. Conduit Couplings and Unions for use with Rigid Nonmetallic Conduit

1. Conduit couplings and unions shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection.

D. Conduit Expansion and Deflection Fittings for use with Rigid Nonmetallic Conduit

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection.

E. Conduit Termination Fittings for use with Rigid Nonmetallic Conduit

1. Conduit hubs shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection. Hubs shall have external threads and an accompanying PVC locknut, and shall be watertight when assembled to an enclosure.

2. Conduit locknuts shall be constructed of zinc plated steel. Locknuts shall have internal threading. Locknuts constructed of PVC and locknuts with integral gasket or seal are not acceptable.

3. Conduit end bells shall be constructed of PVC and shall be smooth inside to accept a glued conduit connection. End bell shall have a smooth inner surface that curves outward towards the edge of the fitting.

2.03 PVC COATED RIGID ALUMINUM CONDUIT AND ASSOCIATED FITTINGS

A. General

1. Where an external coating of polyvinyl chloride (PVC) is specified for conduit and fittings, the coating shall be 40 mil (minimum) thickness. Where an internal coating of urethane is specified for conduit and fittings, the coating shall be 2 mil (minimum) thickness.

2. All conduit fittings shall have a sealing sleeve constructed of PVC which covers all connections to conduit. Sleeves shall be appropriately sized so that no conduit threads will be exposed after assembly.

B. Conduit

1. Conduit shall be made of heavy wall high strength 6063 alloy aluminum with temper designation T1. Conduit shall be manufactured in accordance with ANSI C80.5, and shall be UL 6A Listed.

2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to coating to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.

3. Conduit shall be coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit shall be manufactured in accordance with NEMA RN-1.

C. Conduit Bodies for use with PVC Coated Rigid Aluminum Conduit

1. Conduit bodies shall be constructed of a copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit bodies shall have integral threaded conduit hubs.

2. Conduit bodies for Class I Division I hazardous areas shall be provided with integrally threaded covers constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.

3. Conduit bodies for all other areas shall be constructed of a copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Covers shall be affixed in place by stainless steel screws which thread directly into the conduit body and have a plastic encapsulated head. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

D. Conduit Couplings, Nipples, and Unions for use with PVC Coated Rigid Aluminum Conduit

1. Couplings and nipples shall be threaded and shall be constructed of copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Split-type couplings that use compression to connect conduits are not acceptable.

2. Unions shall be threaded, rain-tight, and constructed of a copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane.

E. Conduit Expansion and Deflection Fittings for use with PVC Coated Rigid Aluminum Conduit

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of a copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Expansion and deflection fittings shall have threaded conduit connections.

2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

F. Conduit Seals for use with PVC Coated Rigid Aluminum Conduit

1. Conduit seals shall be constructed of a copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Conduit seals shall have threaded conduit connections.

G. Conduit Termination Fittings for Use with PVC Coated Rigid Aluminum Conduit

1. Conduit hubs shall be constructed of a copper-free aluminum which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Hubs shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.

2. Conduit bonding bushings shall be constructed of zinc plated malleable iron which is coated on the exterior with a PVC jacket and coated on the interior with a layer of urethane. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

2.04 RIGID ALUMINUM CONDUIT AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be made of heavy wall high strength 6063 alloy aluminum with temper designation T1. Conduit shall be manufactured in accordance with ANSI C80.5, and shall be UL 6A Listed.

2. Conduit shall be provided with factory-cut 3/4 inch per foot tapered threads at each end in accordance with ANSI B1.20.1. Threads shall be cut prior to coating to ensure corrosion protection adequately protects the threads. Conduit shall be provided with a matching coupling on one end and a color-coded thread protector on the other.

B. Conduit Bodies for use with Rigid Aluminum Conduit

1. Conduit bodies shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Conduit bodies shall have integral threaded conduit hubs.

2. Conduit bodies for Class I Division I hazardous areas shall be provided with integrally threaded covers constructed of copper-free aluminum which is coated with an aluminum enamel finish.

3. Conduit bodies for all other areas shall be provided with stamped copper-free aluminum covers that are affixed in place by stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

C. Conduit Couplings, Nipples, and Unions for use with Rigid Aluminum Conduit

1. Couplings and nipples shall be threaded and shall be constructed of heavy wall high strength 6063 alloy aluminum with temper designation T1. Split-type couplings that use compression to connect conduits are not acceptable.

2. Unions shall be threaded, rain-tight, and constructed of copper-free aluminum which is coated with an aluminum enamel finish.

D. Conduit Expansion and Deflection Fittings for use with Rigid Aluminum Conduit

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Expansion and deflection fittings shall have threaded conduit connections.

2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

E. Conduit Seals for use with Rigid Aluminum Conduit

1. Conduit seals shall be constructed of copper-free aluminum which is coated with an aluminum enamel finish. Conduit seals shall have threaded conduit connections.

F. Conduit Termination Fittings for use with Rigid Aluminum Conduit

1. Conduit hubs shall be constructed of copper-free aluminum and shall have threaded connections to the conduit and enclosure. Hubs shall have a plastic insulated throat and shall be watertight when assembled to an enclosure.

2. Conduit locknuts shall be constructed of copper-free aluminum. Locknuts shall have internal threading. Locknuts with integral gasket or seal are not acceptable. Locknuts shall have integral bonding screw where required for proper bonding.

3. Conduit bonding bushings shall be constructed of copper-free aluminum. Bonding bushings shall have a threaded conduit connection. Bonding bushing shall be provided with properly sized set screw for connecting bonding conductor and an integral plastic insulator rated for 150 degrees C located in the throat.

2.05 LIQUID TIGHT FLEXIBLE METAL CONDUIT (LFMC) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be manufactured using a single strip of hot dip galvanized high strength steel alloy, helically formed into a continuously interlocked flexible metal conduit. Trade size 1-1/4 inch and smaller conduits shall be provided with an integrally woven copper bonding strip.

2. Conduit shall be covered with an outside PVC jacket that is UV resistant, moisture-proof, and oil-proof. Conduit shall be UL 360 Listed.

B. Conduit Termination Fittings for use with LFMC

1. Conduit termination fittings shall be constructed of either 304 stainless steel or an electro-galvanized malleable iron alloy which is coated on the exterior with a 40 mil (minimum) PVC jacket and coated on the interior with a 2 mil (minimum) layer of urethane. PVC coated fittings shall have a sealing sleeve constructed of PVC which covers the connection to conduit.

2. Termination fittings shall have a threaded end with matching locknut and sealing ring for termination to equipment, and shall have an integral external bonding lug where required for proper bonding. Termination fittings shall have a plastic insulated throat and shall be watertight when assembled to the conduit and equipment.

2.06 LIQUID TIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be constructed of rigid polyvinyl chloride (PVC), fabricated to provide flexibility. Conduit shall be covered with an outside PVC jacket that is UV resistant, moisture-proof, and oil-proof. Conduit shall be UL 1660 Listed.

B. Conduit Termination Fittings for use with LFNC

1. Conduit termination fittings shall be constructed PVC and shall have a threaded end with matching locknut and sealing ring for termination to equipment. Termination fittings shall be watertight when assembled to the conduit and equipment.

2.07 FLEXIBLE METAL CONDUIT (FMC) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be manufactured using a single strip of hot dip galvanized high strength steel alloy, helically formed into a continuously interlocked flexible metal conduit. Conduit shall be UL 1 Listed.

B. Conduit Termination Fittings for use with FMC

1. Conduit termination fittings shall be constructed of an electro-galvanized malleable iron alloy. Fittings shall have a threaded end with matching locknut for termination to equipment, and a compression-style connection to the associated conduit.

2.08 ELECTRICAL METALLIC TUBING (EMT) AND ASSOCIATED FITTINGS

A. Conduit

1. Conduit shall be hot dipped galvanized on the inside and outside, and made of cold-rolled steel tubing. Conduit shall be manufactured in accordance with C80.3 and shall be UL 797 listed.

B. Conduit Bodies for use with EMT

1. Conduit bodies shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Conduit bodies shall have integral threaded conduit hubs.

2. Conduit bodies shall be provided with galvanized sheet steel covers that are affixed in place by stainless steel screws which thread directly into the conduit body. Covers that utilize wedge nuts or any other method of attachment to the conduit body are not acceptable. Covers shall be provided with matching gasket.

C. Conduit Couplings and Nipples for use with EMT

1. Couplings and nipples shall have threaded compression connectors with associated gland and shall be constructed of electro-galvanized steel. Fittings utilizing a set screw or indenter tool to secure the associated conduit to the fitting are not acceptable. Couplings and nipples shall be rain-tight and have a plastic insulated throat.

D. Conduit Expansion and Deflection Fittings for use with EMT

1. Conduit expansion fittings and conduit deflection fittings shall be constructed of an electro-galvanized malleable iron alloy which is coated with an acrylic paint finish. Expansion and deflection fittings shall have threaded conduit connections.

2. Expansion fittings shall have an integral bonding jumper and deflection fittings shall have an external bonding jumper.

E. Conduit Termination Fittings for use with EMT

1. Conduit termination fittings shall be constructed of electro-galvanized steel and have a plastic insulated throat. Termination fittings shall have a threaded compression connector with associated gland on one end and external threads on the other end. Termination fittings utilizing a set screw or indenter tool to secure the associated conduit to the fitting are not acceptable.

2. Conduit locknuts shall be constructed of zinc plated steel. Locknuts shall have internal threading. Locknuts shall have integral bonding screw where required for proper bonding.

2.09 CONDUIT BENDS

A. Rigid conduit bends, both factory fabricated and field fabricated, shall meet the same requirements listed in the articles above for the respective conduit type and material of construction.

B. Conduit bend radii for standard radius bends shall be no less than as follows:

TRADE SIZE (inches)	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
MIN. RADIUS (inches)	4-1/2	5-3/4	7-1/4	8-1/4	9-1/2	10-1/2	13	15	16	24	30

C. Conduit bend radii for long radius bends shall be no less than as follows:

TRADE SIZE (inches)	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6
MIN. RADIUS (inches)	N/A	12	18	24	30	30	36	36	48	48	60

2.10 MISCELLANEOUS

A. Conduit Periphery Sealing

1. The sealing of the exterior surface of conduits to prevent water and/or air from passing around the conduit periphery from one space to another (where required) shall be through the use of one of the following:

a. A conduit sleeve and pressure bushing sealing system. Acceptable products are FSK by OZ-GEDNEY, Link-Seal by Crouse-Hinds, or Engineer approved equal.

b. A conduit sleeve that is two trade sizes larger than the conduit being sealed, with 2-hour fire rated UL 1479 Listed caulk filling the entire void between the conduit and sleeve. This method is only suitable for penetrations in non-fire rated walls and floors between spaces within buildings. This method shall not be used for the sealing of conduits leaving a building and/or structure.

2. Conduit penetrations through fire-rated walls and floors shall be made with an approved UL 1479 Listed product specifically intended for the trade size of the conduit.

B. Primer and Cement

1. Nonmetallic conduit shall be cleaned with primer and connected to fittings with the manufacturer's recommended cement that is labeled Low VOC.

C. Conduit Interior Sealing

1. The sealing of the inside of conduits against water ingress shall be achieved through the use of one of the following:

a. Two-part expanding polyurethane foam sealing compound, dispensed from a single tube which mixes the two parts as it is injected into the conduit. Expanding foam shall be compatible with the conduit material of construction as well as the outer jacket of the cables in the conduit. Acceptable products are Q-Pak 2000 by Chemque, FST by American Polywater Corporation, or Hydra-seal S-60 by Duraline.

b. Inflatable bag that provides seal around cables and around inside diameter of conduit. Provide appropriate quantity of additional fittings for applications with three or more cables in the conduit to be sealed. Acceptable products are Rayflate by Raychem, or Engineer approved equal. This sealing method is only applicable to conduits trade size 2 inch and larger.

c. Neoprene sealing ring provided with the required quantity and diameter of holes to accommodate the cables in each conduit. Sealing ring shall be compressed by two stainless steel pressure plates. Acceptable products are type CSB by OZ-GEDNEY, or Engineer approved equal. This sealing method is only applicable to metallic conduits containing 4 or less cables.

2. The use of aerosol-based expanding foam sealants or any other method of sealing against water ingress not listed above is not acceptable.

D. Pull Rope

1. Pull ropes for empty and/or spare conduits shall be woven polyester, 1/2 inch wide, with a minimum tensile strength of 1250 lbs.

2. Pull ropes for the Contractors use in installing conductors shall be the size and strength required for the pull, and shall be made of a non-metallic material.

PART 3 – EXECUTION

3.01 GENERAL

A. Minimum trade size for all rigid conduits shall be 3/4 inch in exposed applications and 1 inch in embedded applications. Conduits installed within ductbanks shall be allowed to be increased in size to trade size 2 inch, at the Contractor's option, to accommodate the saddle size of the ductbank spacers. However, no combining of circuits shall be allowed in the larger conduits.

B. Minimum trade size for flexible conduits (where specifically allowed herein) shall be 1/2 inch in all applications.

C. Conduit routing and/or homeruns within structures is not shown on the Drawings. Conduits shall be installed concealed wherever practical and within the limitations specified herein. All other conduits not capable of being installed concealed shall be installed exposed.

D. Empty and/or spare conduits shall be provided with pull ropes which have no less than 12 inches of slack at each end.

E. Nonmetallic conduits for installations requiring less than a factory length of conduit shall be field cut to the required length. The cut shall be made square, cleaned of debris, and primer shall be applied to ready each joint for fusing. Conduits shall then be fused together with the conduit manufacturer's approved cement compound.

F. Metallic conduits for installations requiring less than a factory length of conduit shall be field cut to the required length. The cut shall be made square, be cleaned of all debris and be de-burred, then threaded. Conduit threading performed in the field shall be ¾ inch per foot tapered threads in accordance with ANSI B1.20.1.

G. Conduits shall be protected from moisture, corrosion, and physical damage during construction. Install dust-tight and water-tight conduit fittings on the ends of all conduits immediately after installation and do not remove until conductors are installed.

H. Conduits shall be installed to provide no less than 12 inches clearance from pipes that have the potential to impart heat upon the conduit. Such pipes include, but are not limited to, hot water pipes, steam pipes, exhaust pipes, and blower air pipes. Clearance shall be maintained whether conduit is installed in parallel or in crossing of pipes.

I. Where non-metallic instrumentation conduits are installed exposed, the following clearances to other conduit types shall be maintained:

   1. Instrumentation conduits installed parallel to conduits with conductors energized at 480V or above shall be 18 inches.

   2. Instrumentation conduits installed parallel to conduits with conductors energized at 240V and below shall be 12 inches.

3. Instrumentation conduits installed at right angles to conductors energized at 480V and below shall be 6 inches.

4. Instrumentation conduits installed at right angles to conductors energized at voltages above 480V shall be 12 inches.

J. Where conduit fittings do not include an integral insulated bushing, an insulated bushing shall be installed at all conduit termination points.

K. Conduits which serve multi-section equipment shall be terminated in the section where wiring terminations will be made.

L. Conduits shall not penetrate the floors or walls inside liquid containment areas without specific written authorization from the Engineer. Liquid containment areas are indicated on the Drawings.

M. In no case shall conduit be supported or fastened to another pipe or be installed in a manner that would prevent the removal of other pipes for repairs. Spring steel fasteners may only be used to affix conduits containing lighting branch circuits within EMT conduits to structural steel members.

N. The appropriate specialized tools shall be used for the installation of PVC coated conduit and conduit fittings. No damage to the PVC coating shall occur during installation. Conduit and conduit fittings with damaged PVC coating shall be replaced at the Contractor's cost. The use of PVC coating touch-up compounds is not permitted.

O. Conduits which emerge from within or below concrete encasement shall be PVC coated rigid aluminum in accordance with Standard Detail 1611102 where the conduit is not protected by an equipment enclosure that surrounds the conduit on all sides at the point where it emerges from the encasement.

P. Aluminum conduits shall not be installed in direct contact with concrete surfaces. Where aluminum conduits are routed along concrete surfaces, they shall be installed with one-hole electro-galvanized malleable iron alloy straps with matching clamp-backs to space the conduit ¼ inch away from concrete surface. Where aluminum conduit passes through concrete, CMU or brick walls, the penetration shall be made such that the aluminum conduit does not come in contact with concrete, CMU, brick or mortar.

3.02 CONCEALED AND EMBEDDED CONDUITS

A. Conduits are permitted to be installed concealed and/or embedded with the following requirements:

1. Conduits shall not be installed horizontally when concealed within CMU walls, only vertical installation is acceptable.

2. Conduits installed embedded within concrete floors or walls shall be located so as not to affect the designed structural strength of the floor or wall. Embedded conduits shall be installed in accordance with Standard Detail 0331604 and ACI-318.

3. Where conduit bends emerge from concrete embedment, none of the curved portion of the bend shall be visible. Only the straight portion of the bend shall be visible.

4. Where multiple conduits emerge from concrete embedment or from concealment below a concrete floor, ample clear space shall be provided between conduits to allow for the appropriate and required conduit termination fittings to be installed.

5. Conduits installed embedded within concrete encasement of any kind shall be installed such that conduit couplings for parallel conduits are staggered so that they are not side by side.

B. Conduits are NOT permitted to be installed concealed and/or embedded for the following situations:

1. Conduits shall not be installed embedded within any water-bearing floors or walls. Conduits shall not be installed embedded within any liquid containment area floors or walls.

2. Conduits shall not be installed concealed within CMU walls or gypsum walls that are adjacent to Class I and II hazardous areas (Division I and Division II).

3. Conduits shall not be installed concealed within CMU walls or gypsum walls that are adjacent to indoor Type 1 or Type 2 chemical storage/transfer areas.

3.03 CONDUIT USES AND APPLICATIONS

A. Rigid Conduit

1. Rigid conduit for non-hazardous areas shall be furnished and installed in the materials of construction as follows:

RIGID CONDUIT FOR NON-HAZARDOUS AREAS		
INSTALLATION AREA DESIGNATION/ SCENARIO	**CONDUIT CATEGORY BY WIRING/CIRCUIT TYPE**	
	Power and Control	**Instrumentation**
Exposed in indoor wet process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in indoor dry process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in indoor dry non-process areas	Rigid aluminum conduit	Same as Power and Control
Exposed in outdoor areas	Rigid aluminum conduit	Same as Power and Control
Exposed within pre-fabricated electrical equipment center buildings	Electrical Metallic Tubing	Same as Power and Control

RIGID CONDUIT FOR NON-HAZARDOUS AREAS		
INSTALLATION AREA DESIGNATION/ SCENARIO	**CONDUIT CATEGORY BY WIRING/CIRCUIT TYPE**	
	Power and Control	**Instrumentation**
Concealed within underground direct-bury or concrete-encased ductbanks	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed within non-elevated (i.e. "slab-on-grade" construction) concrete slabs	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed within elevated concrete slabs	PVC coated rigid aluminum conduit	Same as Power and Control
Concealed below concrete slabs (within earth or fill material)	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Emerging from concealment within or below a concrete floor and transitioning to exposed conduit (Reference Detail 1611102)	PVC coated rigid aluminum conduit	Same as Power and Control

2. Rigid conduit for hazardous areas shall be furnished and installed in the materials of construction as follows:

RIGID CONDUIT FOR HAZARDOUS AREAS		
INSTALLATION AREA HAZARD/SCENARIO	**CONDUIT CATEGORY BY WIRING/CIRCUIT TYPE**	
	Power and Control	**Instrumentation**
Exposed in Class I and II areas (Division I and Division II)	Rigid aluminum conduit	Same as Power and Control
Concealed within concrete slabs in Class I and II areas (Division I and Division II)	PVC coated rigid aluminum conduit	Same as Power and Control
Concealed below concrete slabs (within earth or fill material) in Class I and II areas (Division I and Division II)	PVC coated rigid aluminum conduit	Same as Power and Control
Concealed below concrete slabs encased in at least two inches of concrete and buried 24 inches below top of slab in Class I Division I areas	Schedule 40 rigid non-metallic PVC conduit	PVC coated rigid aluminum conduit
Concealed above suspended ceilings in Class I and II areas (Division I and Division II)	Rigid aluminum conduit	Same as Power and Control

3. The tables for the materials of construction for rigid conduits are intended to exhaustively cover all possible scenarios and installation areas under this Contract. However, if a scenario or installation area is found that is not explicitly governed by these tables, it shall be assumed for bid purposes that the conduit material of construction is to be rigid aluminum. This discrepancy shall be brought to the attention of the Engineer (in writing) immediately for resolution.

B. Conduit Bends

1. All conduit bends shall be the same material of construction as the rigid conduit listed in the tables above, with the following exceptions:

   a. All 90 degree bends or combinations of adjacent bends that form a 90 degree bend where concealed within concrete or below a concrete slab shall be PVC coated rigid aluminum.

2. Field fabricated bends of metallic conduit shall be made with a bending machine and shall have no kinks. Field fabricated standard radius and long radius bends shall have minimum bending radii in accordance with the associated tables in Part 2 herein.

3. Field bending of non-metallic conduits is not acceptable, factory fabricated bends shall be used.

4. Long radius bends shall be furnished and installed for the following specific applications, all other bends shall be standard radius:

   a. All conduits containing medium voltage cable.

   b. All conduits containing fiber optic cable.

   c. Where specifically indicated on the Drawings.

C. Flexible Conduit

1. Flexible conduit shall only be installed for the limited applications specified herein. Flexible conduit shall not be installed in any other application without written authorization from the Engineer. Acceptable applications are as follows:

   a. Connections to motors and engine-generator sets (and similar vibrating equipment)

   b. Connections to solenoid valves and limit switches

   c. Connections to lighting fixtures installed in suspended ceilings

   d. Connections to lighting transformers

   e. Connections to pre-fabricated equipment skids

f. Connections to HVAC equipment

g. Connections to instrument transmitters and elements

h. Where specifically indicated in the Standard Details

2. Flexible conduit length shall be limited to three (3) feet, maximum. Flexible conduit shall not be installed buried or embedded within any material.

3. Flexible conduit for non-hazardous areas shall be furnished and installed in the materials of construction as follows:

FLEXIBLE CONDUIT FOR NON-HAZARDOUS AREAS		
INSTALLATION AREA DESIGNATION/SCENARIO	**CONDUIT CATEGORY BY WIRING/CIRCUIT TYPE**	
	Power and Control	**Instrumentation**
Exposed in indoor wet process areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in indoor dry process areas	Flexible metal conduit	Same as Power and Control
Exposed in indoor dry non-process areas	Flexible metal conduit	Same as Power and Control
Exposed in indoor Type 1 chemical storage/transfer areas	Liquid-tight flexible non-metallic conduit	Same as Power and Control
Exposed in indoor Type 2 chemical storage/transfer areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in outdoor areas	Liquid-tight flexible metal conduit	Same as Power and Control
Concealed above suspended ceilings (all indoor areas)	Same material as exposed conduit in same area	Same as Power and Control

4. For Class I Division I hazardous areas, the NEC does not permit the installation of flexible conduit. In lieu of flexible conduit in these areas, flexible conduit couplings shall be installed as specified in Part 2 herein. Flexible conduit for all other hazardous areas shall be furnished and installed in the materials of construction as follows:

FLEXIBLE CONDUIT FOR HAZARDOUS AREAS		
INSTALLATION AREA HAZARD/SCENARIO	**CONDUIT CATEGORY BY WIRING/CIRCUIT TYPE**	
	Power and Control	**Instrumentation**
Exposed in Class I Division II areas	Liquid-tight flexible metal conduit	Same as Power and Control
Exposed in Class II (Division I and Division II) areas	Liquid-tight flexible metal conduit	Same as Power and Control
Concealed above suspended ceilings in Class I and II (Division I and Division II) areas	Same material as exposed conduit in same area	Same as Power and Control

3.04 CONDUIT FITTING USES AND APPLICATIONS

A. General

1. Conduit fittings shall be furnished and installed in the materials of construction as indicated in Part 2, herein. Conduit fitting materials of construction are dependent on the material of construction used for the associated conduit.

2. Conduit fittings shall be provided in the trade size and configuration required to suit the application.

B. Conduit Bodies

1. Conduit bodies shall be installed where wire pulling points are desired or required, or where changes in conduit direction or breaking around beams is required.

2. Where conduit bodies larger than trade size 2 inches are intended to be used as a pull-through fitting during wire installation, oversized or elongated conduit bodies shall be used. Oversized or elongated conduit bodies shall not be required if the conduit body is intended to be used as a pull-out point during wire installation.

C. Conduit Nipples and Unions

1. Conduits with running threads shall not be used in place of 3-piece couplings (unions) or close nipples. After installation of a conduit fitting of any kind, there shall be no more than ¼ inch of exposed threads visible. Factory fabricated all-thread nipples may be used between adjacent enclosures, however, the same restriction applies regarding the length of exposed threads that are visible.

D. Conduit Expansion and Deflection Fittings

1. Conduit expansion fittings shall be installed where required by the NEC and where indicated on the Drawings. Expansion fittings shall also be installed for exposed straight metallic conduit runs of more than 75 feet, in both indoor and outdoor locations. Expansion fittings for runs of non-metallic conduit shall be installed in accordance with the NEC.

2. Conduit deflection fittings shall be installed where required by the NEC and where conduits are installed (exposed and concealed) across structural expansion joints.

E. Conduit Seals

1. Conduit seals shall be installed for conduits installed within or associated with hazardous areas and other areas as required by the NEC.

F. Conduit Termination Fittings

1. Where conduits terminate at enclosures with a NEMA 4, 4X, or 3R rating and the enclosure does not have integral conduit hubs, an appropriately sized watertight conduit hub shall be installed to maintain the integrity of the enclosure. The use of locknuts with integral gasket in lieu of watertight conduit hubs is not acceptable.

2. Where conduits terminate at enclosures that do not require conduit hubs, a two-locknut system shall be used to secure the conduit to the enclosure. One locknut shall be installed on the outside of the enclosure, and the other inside, drawn tight against the enclosure wall. The locknut on the interior of the enclosure shall be the type with integral bonding lug, or a conduit bonding bushing may be used in place of the locknut.

3. Conduits shall not be installed such that conduit fittings penetrate the top of any enclosure located outdoors, except in cases where specifically required by the serving electric utility. Conduits which serve outdoor equipment or an enclosure from above shall instead be routed into the side of the enclosure at the bottom. The conduit termination fitting shall be provided with a conduit drain to divert moisture from the raceway away from the enclosure.

3.05 MISCELLANEOUS

A. Conduit Periphery Sealing

1. All conduit penetrations through exterior walls shall be sealed around the periphery using the appropriate products specified in Part 2 herein to prevent air and/or water entry into the structure.

2. All conduit penetrations through interior walls and floors shall be sealed through the use of with conduit sleeves and caulk as specified in Part 2 herein. Alternatively, mortar may be used to seal around the conduit periphery.

3. Conduit penetrations through fire-rated walls as floors shall be made with the appropriate fire rated penetration product.

B. Conduit Interior Sealing

1. All conduits (including spares) entering a structure below grade shall be sealed on the interior of the conduit against water ingress. Sealing shall be at an accessible location in the conduit system located within the building structure and shall be via one of the methods specified in Part 2 herein. If conduit sealing cannot be achieved

at an accessible location within the building structure, sealing shall be placed in the conduits in the nearest manhole or handhole outside the structure.

3.06 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. All conduit installed below grade or concrete encased shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of a suitable pulling rope.

3.07 TRAINING OF INSTALLATION PERSONNEL

A. All Contractor personnel that install PVC coated aluminum conduit shall be trained by the PVC coated aluminum conduit manufacturer. Training shall include proper conduit system assembly techniques, use of tools appropriate for coated conduit systems, and field bending/cutting/threading of coated conduit. Training shall have been completed within the past 24 months prior to the Notice to Proceed on this Contract to be considered valid. Contractor personnel not trained within this timeframe shall not be allowed to install coated conduit, or shall be trained/re-trained as required prior to commencement of conduit installation.

- END OF SECTION -

SECTION 16118

UNDERGROUND ELECTRICAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install underground duct systems, electric manholes, and electric handholes as specified herein and as indicated on the Drawings. The work shall be complete and shall include excavation, concrete construction, backfilling, and all materials, items, and components required for a complete system.

B. The provisions of this Division are applicable to all underground conduit work. All work shall be coordinated with that of the various utility companies and other Contractors. The Contractor shall adhere to all utility company requirements including the serving electric utility.

C. Reference Section 16000, Basic Electrical Requirements; Section 16111, Conduit; Section 16121, Medium Voltage Cable; Section 16170, Grounding and Bonding; the applicable sections of Division 2, Sitework; Section 03200, Reinforcing Steel; and 03300, Cast-In-Place Concrete.

1.02 CODES AND STANDARDS

A. Products specified herein shall be designed, manufactured, and/or listed to the following standards as applicable:

1. AASHTO H20

2. ANSI/SCTE 77-2010 – Specification for Underground Enclosure Integrity

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit Shop Drawings. Each submittal shall be identified by the applicable Specification Section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

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C. Shop drawings shall include but not be limited to, the following:

1. Product data sheets.

2. Outline and dimensional drawings including detailed sections of the manholes and/or handholes.

3. Materials specifications and structural calculations for the manholes sealed by a Professional Engineer in the State of South Carolina.

1.05 IDENTIFICATION

A. Each electric manhole and handhole cover shall be lettered with the word “Electric”, the manhole or handhole identification number (e.g. EMH-1, EHH-1, etc.), manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings.

2.02 DUCT SYSTEM

A. The underground duct system shall be comprised of conduits, conduit bends, and conduit fittings as specified in Section 16111, Conduit. Conduits shall be encased in reinforced concrete envelopes, unless otherwise specified herein or indicated on the Drawings.

B. Base and intermediate conduit spacers shall be furnished to provide a minimum of two-inch (2”) separation between conduits. Conduit spacers shall be provided in the proper size as required for the conduit that they secure. For example, a 4” conduit spacer shall not be used to secure a 2” conduit. Conduit spacers shall be as manufactured by Carlon Electrical Products Company, Aeroquip Corporation, Underground Devices, Incorporated, or equal.

2.03 ELECTRIC MANHOLES

A. The concrete manholes shall be complete with metal frames and covers of size and location as specified herein and shown on the Drawings.

B. Manhole frames and covers shall be Neenah R-1640C1, or equal, with Type A anchor ring. Entire manhole assembly shall be AASHTO H20 heavy duty rated. Covers shall be furnished with drop handles.

C. All medium voltage cables installed in the manholes shall be arc and fireproofed in accordance with specification Section 16121.

D. All electric manholes shall be provided with non-metallic cable racks. Cable racks shall be rated for the application, with a minimum loading capacity of 450lbs per rack arm. Cable rack system shall be Heavy Duty type as manufactured by Underground Devices, Incorporated or equal.

2.04 ELECTRIC HANDHOLES

A. The electric handholes shall be a precast polymer concrete enclosure suitable for use as part of an underground electric raceway system. The enclosure shall meet or exceed the requirements of ANSI/SCTE 77-2010.

B. The enclosure and cover design and test load rating shall be Tier 15. Covers shall be provided with cover hooks.

C. The enclosure shall be the straight side design to allow easy adjustment of box to grade. The box shall be stackable for increased depth.

D. Handhole opening size shall be as required to suit the application, 6" X 8", minimum.

E. The electric handholes shall be manufactured by Hubbell, Pencell Plastics equivalent, Highline Products equivalent, or equal.

PART 3 -- EXECUTION

3.01 GENERAL

A. The underground duct system, manholes, and handholes shall be installed as specified herein, indicated on the Drawings, and in accordance with manufacturers' instructions.

3.02 DUCT SYSTEM

A. All underground conduit shall be encased in concrete and shall be reinforced. Encasement and reinforcement shall be as indicated in the standard details. Concrete shall be furnished and installed in accordance with Section 03300. Reinforcing steel shall be furnished and installed in accordance with Section 03200. Concrete electrical duct banks shall contain red dye; the red dye shall be mixed into the concrete mix before being poured. Red dye applied to the top of concrete encasement after placement of concrete is not acceptable.

B. Concrete pours shall be complete from handhole to handhole and from manhole to manhole where practicable. Partial pours in general shall not be permitted. Where a complete pour is impractical, written authorization shall be obtained from the Engineer for the partial pour.

C. Conduit ductbank elevations at the manholes and handholes shall be based on minimum ductbank cover as indicated in the standard details, or deeper to avoid conflicts with other obstacles. Where deviation is necessary to clear unforeseen obstacles, the elevations may be changed after authorization by the Engineer.

D. Slope all conduits continuously away from structures and buildings with a minimum slope of 3" per 100' unless otherwise indicated on the Drawings.

E. The minimum clearance from the top of the concrete encasement and finished grade shall be as indicated in the standard details, except where otherwise accepted in writing by the Engineer or shown on the Drawings.

F. Care shall be exercised during excavation for the duct banks to prevent digging too deep. Backfilling of low spots with earth fill will not be permitted unless thoroughly compacted and acceptable to the Engineer.

G. Where no specific ductbank arrangement is shown on the Drawings, the Contractor shall arrange conduits within each ductbank based on field conditions. Spare conduits shown going from ductbanks into buildings or structures shall be stubbed up in the location(s) as indicated on the Drawings.

H. A minimum of one (1) ground rod, furnished in accordance with Section 16170, shall be driven adjacent to each manhole, handhole, or other concrete box. A No. 4/0 AWG bare copper ground cable shall be connected between this rod and the copper ground strap using a silicon bronze connector. All ground rods shall be interconnected by means of the No. 4/0 AWG bare copper ground cable located within each duct bank. The ends of these cables shall also be connected to substation and/or building ground buses where the conduits terminate.

I. Care shall be exercised and temporary plugs shall be installed during installation to prevent the entrance of concrete, mortar, or other foreign matter into the conduit system. Conduit spacers shall be utilized to support conduit during the pouring of concrete to prevent movement and misalignment of the conduits. Conduit spacers shall be installed in accordance with manufacturer's instructions unless otherwise noted. Horizontal spacing of conduit spacers along ductbank shall be as indicated on the Standard Details.

J. Where connections to existing underground conduits are indicated, excavate to the maximum depth necessary. After addressing the existing conductors, cut the conduits and remove loose concrete from the conduits before installing new concrete encased ducts. Provide a reinforced concrete collar, poured monolithically with the new duct line, to take the shear at the joint of the duct lines.

K. Construct concrete-encased conduits connecting to underground structures to have a flared section adjacent to the manhole to provide shear strength. Construct underground structures to provide shear strength. Construct underground structures to provide for keying the concrete encasement of the duct line into the wall of the structure. Use vibrators when this portion of the encasement is poured to ensure a seal between the encasement and the wall of the structure.

L. Six (6) inches above all duct banks, the Contractor shall furnish and install a two (2) inch wide red plastic electrical hazard tape. Tapes shall be metallic detectable type and shall have a continuous message in bold black letters: "ELECTRIC LINE BURIED BELOW." Tape shall be Detectable Identoline by Brady, or equal.

M. The Contractor shall perform all earthwork including excavation, backfill, bedding, compaction, shoring and bracing, grading and restoration of surfaces and seeded areas disturbed during the execution of the work.

N. All conduit joints in the duct system shall be staggered such that adjacent conduits do not have joints in the same location.

3.03 ELECTRIC MANHOLES

A. Electric manholes shall be installed to a sufficient depth to accommodate the required grading of ducts as well as maintaining a minimum distance of 14" from the bottom of the lowest duct centerline entrances to finished floor line and/or highest duct centerline entrance to the roof. All manholes shall be built on, or placed over a 6" layer of well-tamped gravel.

B. Duct envelopes and conduit with bell ends shall enter at approximately right angles to the walls, except as may otherwise be shown on the Drawings.

C. All concrete work and fully assembled manholes shall be completely watertight and shall be furnished with sloped floors that pitch towards a sump pit. The outside surfaces shall be coated with an approved asphaltic waterproofing compound (all sides, bottom, and roof). Precast concrete manholes may be installed; however, all requirements of this section and other divisions of the Specifications and the details shown on the Drawings shall apply.

D. Install pulling eye irons imbedded in walls opposite each duct entrance securely fastened to manhole reinforcing rods. All hardware shall be hot-dipped galvanized steel. Copper bars shall be provided in the walls for grounding. No. 4/0 AWG bare copper cables shall be connected to these bars and all non-current carrying metal parts shall be grounded to these copper bars.

E. All cables shall be well supported on walls by nonmetallic cable racks. The cable racks shall be heavy-duty type for medium and low voltage power cables and light duty type for control, signal, communications and similar small conductors. All racks shall be rigidly attached to the wall and equipped with adjustable rack arms.

3.04 ELECTRIC HANDHOLES

A. Electric handholes shall be installed to a sufficient depth to accommodate the required grading of ducts as well as maintaining a minimum distance of 9" from the bottom of the lowest duct centerline entrances to finished floor line and/or highest duct centerline entrance to roof. All handholes shall be built on, or placed over a 6" layer of well-tamped gravel.

B. Duct envelopes and conduit with bell ends shall enter at approximately right angles to the walls, except as may otherwise be shown on the Drawings.

C. All fully assembled handholes shall be completely watertight.

D. All individual cables and/or bundles of conductors shall be identified and “dressed” along the wall of the enclosure. Cable racks as specified herein shall be provided if any handhole dimension exceeds 24 inches.

3.05 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Field tests

a. Field tests for all completed duct systems shall consist of pulling a swab through each conduit followed by a mandrel equal in size to 85% of the conduit inside diameter.

b. After testing, all conduits shall be capped after installation of a suitable pull rope. All field tests shall be witnessed by the Engineer.

- END OF SECTION -

SECTION 16121

MEDIUM VOLTAGE CABLE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all medium voltage cables indicated on the Drawings, as specified herein, or required for proper operation of the installation. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All appurtenances required for the installation of medium voltage cable systems shall be furnished and installed by the Contractor.

B. The scope of this Section does not include internal wiring factory installed by medium voltage electrical equipment manufacturers.

C. The manufacturer(s) shall furnish a twenty-five (25) year product warranty on all supplied medium voltage cables and a ten (10) year warranty on splices and terminations.

D. All Contractor personnel installing medium voltage splices or terminations shall be trained as specified in Part 3, Execution, of this Specification.

E. Reference Section 16000 – Basic Electrical Requirements.

1.02 CODES AND STANDARDS

A. Medium voltage cables and appurtenances shall be designed, manufactured, and/or listed to the following standards as applicable:

1. Underwriters Laboratories (UL)

a. UL 486A-486B – Standard for Safety Wire Connectors
b. UL 1072 – Standard for Medium-Voltage Power Cables
c. UL 1685 – Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

2. American National Standards Institute (ANSI)

a. ANSI C119.1 - Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
b. ANSI WC 53 – Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test

3. American Society for Testing and Materials (ASTM)

a. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire
b. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
c. ASTM B496 – Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
d. ASTM D149 – Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
e. ASTM D150 – Standard Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
f. ASTM D412 – Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
g. ASTM D2303 – Standard Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials
h. ASTM D2754 – Standard Specification for High-Temperature Glass Cloth Pressure-Sensitive Electrical Insulating Tape

4. National Electrical Manufacturers Association

a. NEMA WC 53 – Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test
b. NEMA WC 74 - 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

5. Insulated Cable Engineers Association (ICEA)

a. ICEA T-27-581 – Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test
b. ICEA S-93-639 - 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
c. ICEA S-97-682 – Standard for Utility Shielded Power Cables Rated 5 Through 46 kV

6. Institute of Electrical and Electronics Engineers (IEEE)

a. IEEE 48 – Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
b. IEEE 386 – Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600 V
c. IEEE 404 – Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV
d. IEEE 1202 – Standard for Flame Testing of Cables

7. Association of Edison Illuminating Companies (AEIC)

   a. AEIC CS8 – Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300 – Submittals, the Contractor shall obtain from the cable manufacturer and submit the following:

   1. Shop Drawings

   2. Reports of Certified Shop and Field Tests

   3. Wiring Identification Methods.

   4. Certificates of training for termination and splice installers.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed materials' compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

   1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

   2. Product data sheets.

   3. Cable pulling calculations.

4. Cable identification methods and materials.

5. Medium voltage splicing and termination product data sheets.

6. The cable manufacturer's recommended maximum test voltage and time duration values for field acceptance testing.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 IDENTIFICATION

A. Each cable shall be identified as specified in Part 3, Execution, of this Specification.

1.06 CABLE PULLING CALCULATIONS

A. The Contractor shall submit cable pulling calculations for approval prior to making each cable pull. These calculations, to be performed by a currently registered professional engineer in the State of South Carolina, shall define pulling tension and sidewall loading (sidewall bearing pressure values) for all medium voltage cable installations.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The cables to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing medium voltage cables for a minimum of ten (10) years. Cables shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings. Only one (1) manufacturer for each cable type shall be permitted.

B. The cable manufacturer shall be ISO 9000 registered.

2.02 SHIELDED POWER CABLE (ALL VOLTAGE CLASSES)

A. Except where specified otherwise herein, the requirements of this section shall apply to all voltage classes of medium voltage shielded power cable (5kV/8kV, 15kV, 25kV, and 35kV).

B. The cable to be furnished and installed for medium voltage circuits shall be shielded power cable, UL Listed as NEC Type MV-105. The voltage class of the cable for each circuit shall be as indicated on the Drawings, or if not shown, as approved by the Engineer. In no case shall the voltage rating of the shielded power cable be less than the voltage rating of the circuit being supplied by the cable.

B. The conductor shall be annealed bare copper per ASTM B3, Class B compact or compressed stranded per ASTM B8 or B-496, with an extruded thermoset semiconducting EPR conductor shield/screen (i.e. strand shield/screen). The conductor screen shall meet or exceed the electrical and physical requirements of ICEA S-93-639 (NEMA WC74) and S-97-682, AEIC CS8, and UL 1072.

C. The insulation shall be an ethylene-propylene rubber (EPR) based thermosetting compound which meets or exceeds the electrical and physical requirements of ICEA S-93-639 (NEMA WC74) and S-97-682, AEIC CS8, and UL 1072. Insulation level shall be 133% for the respective voltage class, and as specified elsewhere herein.

D. A thermoset extruded semiconducting insulation screen shall be extruded directly over the insulation and shall be easily strippable without the use of a release agent. The insulation screen shall meet or exceed the electrical and physical requirements of ICEA S-93-639 (NEMA WC74) and S-97-682, AEIC CS8, and UL 1072. The insulation thickness and voltage rating shall be as specified herein.

E. The semiconducting conductor shield/screen, insulation, and semiconducting insulation screen shall be simultaneously extruded utilizing an enclosed, true triple extrusion process to prevent contamination of the conductor shield/screen, insulation, and insulation shield.

F. The metallic insulation shield shall be a 5 mil bare copper tape helically applied over the insulation with a nominal 25% percent overlap. Cables using corrugated shield/drain wires are not acceptable.

G. The cable jacket shall be flame-retardant, moisture, abrasion, and sunlight-resistant PVC which meets or exceeds the electrical and physical requirements of ICEA S-93-639 (NEMA WC74) and S-97-682, and UL 1072. Sizes #1/0 AWG and larger shall be shall be listed and marked “Sunlight- Resistant FOR CT USE” in accordance with the NEC.

H. The shielded power cable shall be Okoguard-Okoseal as manufactured by the Okonite Company, Uniblend XLF PVC High Speed as manufactured by General Cable, SIMpull CT1 ET as manufactured by Southwire Company equivalent.

2.03 5kV/8kV SHIELDED POWER CABLE

A. The insulation for 5kV/8kV shielded power cables shall be 115 mils, rated 5kV-133% insulation level or 8kV-100% insulation level.

2.04 15kV SHIELDED POWER CABLE

A. The insulation for 15kV shielded power cables shall be 220 mils, rated 15kV-133% insulation level.

2.05 25kV SHIELDED POWER CABLE

A. The insulation for 25kV shielded power cables shall be 320 mils, rated 25kV-133% insulation level. Insulation that is 345 mils, rated 25kV-133% insulation level or 35kV-100% insulation level is also acceptable.

2.06 35kV SHIELDED POWER CABLE

A. The insulation for 35kV shielded power cables shall be 420 mils, rated 35kV-133% insulation level.

2.07 5-35kV SHIELDED POWER CABLE TERMINATIONS

A. Shielded power cable termination kits shall be factory engineered for the application. The insulator material for the termination shall be suitable for outdoor applications and made from UV-stable, non-tracking (per ASTM D2303) materials. Sealant materials to help prevent moisture ingress and contamination shall also be included. All terminations shall meet or exceed all rating requirements for IEEE 48 Class 1 terminations. These terminations shall meet the test sequence requirements prescribed by IEEE 48, including 130°C load cycling and 130°C impulse withstand.

B. In "Heavy" or "Extremely Heavy" environments, as classified by IEEE-48, terminations shall consist of a heat shrinkable outer insulating tubing coated internally with a stress control material or a heat shrinkable outer insulating tubing and a separate heat shrinkable stress control tubing. Heat-activated sealant materials to help prevent moisture ingress and contamination shall also be included. These terminations shall meet the test sequence requirements prescribed by IEEE 48, including 140°C load cycling and 140°C impulse withstand.

C. The terminations shall be manufactured by The 3M Company, Tyco Electronics (Raychem), or equal.

2.08 5-35kV SHIELDED POWER CABLE SPLICES

A. Power cable splices shall be factory-engineered kits that rebuild the primary cable insulation, shielding and grounding systems, and outer jacket equivalent to that of the original cable. When assembled on the cable, the splice shall be capable of passing the electrical test requirements of IEEE 404, and the water immersion tests of ANSI C119.1. Splices shall be suitable for direct-burial, manhole, cable tray, and UV exposed areas. Pre-molded splices are not acceptable. Taped splices are not acceptable.

B. The splices shall provide a positive moisture seal provided by heat activated or pressure activated sealant.

C. The splices shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. Splices shall be capable of being properly installed on out-of-round cables per relevant ICEA and AEIC standards.

D. Splices for armored cables shall provide a means of reinstating the armor over the span of the installed splices.

E. Heat shrinkable splices shall meet the 140°C load cycling and 140°C impulse withstand requirements of IEEE 404.

F. Heat shrinkable splices shall be of a uniform-cross-section heat shrinkable polymeric construction. Internal moisture seals shall inhibit migration of moisture from other sections of the cable where jacket damage may have occurred.

G. Single component cold shrinkable splices shall be molded from silicone rubber and have integrated stress relief cones and a faraday cage. It is preferred to have integrated on a single spiral holdout: the splice body, metallic shield, and re-jacketing sleeve. The integrated metallic shield shall be a flexible copper sock capable of carrying the neutral current with ampacity greater than or equal to 1/0AWG copper. The re-jacketing sleeve shall be extruded from EPDM rubber. The re-jacketing sleeve shall provide a tight interference fit with the cable jacket and supplied sealing mastic in order to assure an environmental seal per IEEE 404.

H. In “Heavy” or “Extremely Heavy” environments as classified by IEEE 48, heat shrinkable splices are preferred.

I. The splice manufacturer shall provide a test report demonstrating compliance with the above requirements.

J. Modular splicing kits, utilizing separable connectors which bolt together, may only be used if specifically approved, in writing, by the Engineer. Modular splicing kits shall be rated for 5-25kV, 600A, and shall meet or exceed the requirements of IEEE 386.

K. The splices shall be manufactured by The 3M Company, Tyco Electronics (Raychem), or equal.

2.09 CABLE PULLING LUBRICANTS

A. Cable pulling lubricants shall be non-hardening type, and approved for use on the type of cable installed. Lubricant shall be Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equal.

PART 3 -- EXECUTION

3.01 GENERAL

A. The cables shall be installed as specified herein and indicated on the Drawings.

B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

C. The Contractor shall furnish and install dead front, 200A load break or 600A non-load break (i.e. “dead break”), elbow terminators for the primary cables to the pad-mount transformers, existing pad mounted switches, and other equipment requiring such connectors. Elbow terminators shall meet or exceed the requirements of IEEE 386. The elbow terminators shall be manufactured by The 3M Company, Tyco Electronics (Raychem), or equal.

D. **Splices shall not be allowed in any medium voltage cables.** If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing. Splicing material shall be as specified herein and as accepted by the Engineer.

E. Cable Sizes

1. The sizes of cable shall be as indicated on the Drawings, or if not shown, as approved by the Engineer.

F. Cable Identification

1. Identify 25kV/35kV Class cables by the use of four (4) strips of identification tape. Identify 15kV Class cables by the use of three (3) strips of identification tape. Identify 5kV/8kV Class cables by the use of the two (2) strips of identification tape

2. All cables shall be identified at each point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where a termination is made. The Contractor shall meet with the Owner and Engineer to come to an agreement regarding a cable identification system prior to installation of any cables. Cable numbers, where applicable, shall not be duplicated.

3. Cable identification in manholes, pull boxes, vaults, and other accessible components in the raceway system where the cables are continuous shall be accomplished by means of a tag installed around the bundled group of conductors. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all of the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that particular conduit number in the conduit and wire schedule. Minimum text size shall be 10 point. The tag shall be affixed to the cable bundle by the use of nylon wire ties, and shall be made of polyethylene as manufactured by Brady, Seton equivalent, Panduit equivalent, or equal.

G. Cable Arc and Fireproofing

1. All medium voltage cables installed in manholes, pull boxes, vaults, and other accessible components in the raceway system shall be arc and fireproofed utilizing one of the following tape systems:

Plymouth Rubber Group

a. 53 PLYARC Arc and Fireproofing Tape

(1) 3 inches wide with a thickness of 30 mils.
(2) Tape shall be wrapped around cable in one half-lapped layer.

b. 77 PLYGLAS Glass Cloth Tape

(1) 7 mils thickness.
(2) Tape shall be utilized to secure the 53 PLYARC.
(3) Tape shall be in accordance with ASTM D-2754.

OR

The 3M Company

c. Scotch 77 Fire and Electric Arc Proofing Tape

(1) 1.5 inches or 3 inches wide, depending upon cable diameter and in accordance with the manufacturer's installation instructions, with a thickness of 30 mils.
(2) Tape shall be wrapped around cable in one half-lapped layer.

d. Scotch 69 Glass Cloth Tape

(1) 7 mils thickness.
(2) Tape shall be utilized to secure the Scotch 77.
(3) Tape shall be in accordance with ASTM D-2754.

Each individual cable shall be individually arc and fireproofed 6" into the duct. Multiple cables within a single wrap of fireproofing tape shall not be permitted.

H. Training of Cable

1. The Contractor shall furnish all labor and material required to train cables around cable vaults within buildings, and in manholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each manhole and vault so that the cable can be trained and racked in an approved manner. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. All manhole cables shall be arc and fire-proofed. The training shall be done in such a manner as to minimize chaffing. Reference Section 16118 – Underground Electrical.

I. Connections at Equipment

1. Connections at equipment shall be made in accordance with the best practices of the trade, and the cable and/or termination product manufacturer's instructions for the particular type of cable.

J. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less within a three (3) day period prior to pulling, the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the work day for which the cable is removed from the protected storage. Any remaining cable reels shall be returned to storage at the completion of the workday.

3.02 MEDIUM VOLTAGE CABLE INSTALLATION

A. Medium voltage cable shall be installed so that no damage occurs to the insulation or outer jacket. Cable shall not be bent or twisted such that the tape shield is pulled apart. The tape shield shall be twisted and grounded at each termination.

B. Terminations shall be made with stress control kits in freestanding equipment and loadbreak elbows in pad mounted equipment. Terminations shall meet or exceed the ratings of the cable and the interrupting capacity of the connected equipment. Terminations shall be as specified in Part 2, Products, of this Specification.

C. All splices and terminations shall be in compliance with the cable and splice/termination manufacturer's recommendations. These recommendations shall be submitted to the Engineer for review one (1) week prior to making any splices or terminations.

D. Installers shall be trained by the factory supplying medium voltage terminations and splices in the proper installation of the products. Installers shall be able to produce evidence of such training within the past three (3) years. This evidence shall be submitted to the Engineer for review one (1) week prior to making any splices or terminations.

3.02 MATERIAL STORAGE AND HANDLING

A. The Contractor shall inspect the cable and reels upon receipt for visible or hidden damage. Reels should not be shipped on their side, and should be shipped with a protective cover over the cable on the reel. Reels turned over onto their side are subject to damage. Reels shall not be rolled-off the truck or lifted by forks on the drum. Reels shall be lifted by a chain connected to a spreader bar through the arbor hole. Reel ends shall be covered by a heat-shrinkable end cap upon shipment, and again each time a cable end has been cut from the reel. The Contractor shall note any damage that has been identified on the bill of lading and take photos of the damage at the time of delivery. Any damage shall be reported to the engineer, project management, and cable distributor, and such report(s) shall include the photos of the damage.

B. Cable reels shall be stored in areas away from high traffic (where it may be subject to damage).

3.04 TESTING

A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Shop Tests

a. Cables shall be tested in accordance with the applicable ICEA Standards. Cables shall be physically and electrically tested in accordance with the manufacturer’s standards.

b. Cable shall be tested at the factory in accordance with AEIC CS8 (latest revision) except that the cable shall be corona free when tested at 200 VAC per mil and 363 VDC per mil. Corona test results to be available on an X-Y plot. Tests shall be as described by ICEA S-93-639 (NEMA WC74), Section 6 or ICEA T-27-581 (NEMA WC53).

2. Field Tests

a. Field testing shall be performed in accordance with NETA Acceptance Testing Specifications (ATS), latest edition.

b. After installation, all medium voltage cables shall be tested for insulation levels and continuity in accordance with NETA test documents and the cable manufacturer's recommendations. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

(1) Cable shall be given a conductor continuity check and a high voltage DC field acceptance test after installation. The DC test voltage shall be in accordance with AEIC CS8, however shall not exceed the cable manufacturer's recommended maximum test voltage and time duration.

B. Medium voltage cables shall be tested before being connected to equipment.

C. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner. All conductors of a multi-phase circuit shall be replaced if one conductor fails the required testing. If part of a multi-set (parallel conductors per phase) circuit fails testing, only the set containing failure shall be replaced.

D. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment. Test reports shall be submitted to the Engineer.

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SECTION 16123

LOW VOLTAGE WIRE AND CABLE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, all low voltage wire and cable indicated on the Drawings and as specified herein and/or required for proper operation. The work of connecting cables to equipment and devices shall be considered a part of this Section. All appurtenances required for the installation of wire and cable systems shall be furnished and installed by the Contractor.

B. The scope of this Section does not include internal wiring factory installed by electrical equipment manufacturers.

C. Reference Section 16000 – Basic Electrical Requirements and Section 16130 – Boxes.

1.02 CODES AND STANDARDS

A. Low voltage wire, cable, and appurtenances shall be designed, manufactured, and/or listed to the following standards as applicable:

1. Underwriters Laboratories (UL)

a. UL 13 – Standard for Power-Limited Circuit Cables

b. UL 44 – Thermoset-Insulated Wires and Cables

c. UL 83 – Thermoplastic-Insulated Wires and Cables

d. UL 1277 – Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members

e. UL 1581 – Reference Standard for Electrical Wires, Cables, and Flexible Cords

f. UL 1685 – Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

g. UL 2250 – Standard for Instrumentation Tray Cable

h. UL 2556 – Wire and Cable Test Methods

2. American Society for Testing and Materials (ASTM)

a. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire

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b. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

c. ASTM B33 – Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes

d. ASTM D69 – Standard Test Methods for Friction Tapes

e. ASTM D4388 – Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes

3. Insulated Cable Engineers Association (ICEA)

a. ICEA S-58-679 – Standard for Control, Instrumentation and Thermocouple Extension Conductor Identification

b. ICEA T-29-250 – Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 210,000 B.T.U./Hour

4. Institute of Electrical and Electronics Engineers (IEEE)

a. IEEE 1202 – Standard for Flame Testing of Cables

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300 – Submittals, the Contractor shall obtain from the wire and cable manufacturer and submit the following:

1. Shop Drawings

2. Reports of Field Tests

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets for wire and cable, terminations, and pulling lubricant.

2. Cable pulling calculations (if required).

3. Wiring identification methods and materials.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 CABLE PULLING CALCULATIONS

A. Prior to the installation of the wire and cable specified herein, the Contractor shall submit cable pulling calculations for engineer review and approval when all of the following are true:

1. The amount of cable to be installed will be greater than 200 linear feet between pull points.

2. The installation will have one or more bends.

3. The wire and cable is size #1/0 AWG and larger.

B. Cable pulling calculations shall be performed by a currently registered professional engineer in the State of South Carolina and shall define pulling tension and sidewall loading (sidewall bearing pressure values).

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years. Wire and cable shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings. Only one (1) manufacturer for each wire and cable type shall be permitted.

2.02 POWER AND CONTROL WIRE AND CABLE

A. Power and control wire shall consist of insulated copper conductors with a nylon (or equivalent) outer jacket. Conductor insulation shall be rated 90°C for dry locations, 75°C for wet locations, and 600V. Insulated conductors shall be UL 83 Listed as NEC Type THHN/THWN.

B. Unless specified otherwise herein, conductors shall be stranded copper per ASTM B-8 and B-3, with Class B or C stranding contingent upon the size. Power conductors for lighting and receptacle branch circuits shall be solid copper per ASTM B-3.

C. Power conductor size shall be no smaller than No. 12 AWG and Control conductor size shall be no smaller than No. 14 AWG.

D. Multi-conductor cable assemblies shall include a grounding conductor and an overall PVC jacket. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Multi-conductor cable assemblies shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).

E. Power wire and cable shall be as manufactured by the Okonite Company, the Southwire Company, or General Cable.

2.03 INSTRUMENTATION CABLE

A. For single-analog signal applications, instrumentation cable shall consist of a single, twisted pair or triad of individually insulated and jacketed copper conductors with an overall cable shield and jacket. Conductor insulation shall be rated 90°C in both wet and dry locations, and 600V. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Cable shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).

B. For multiple-analog signal applications, instrumentation cable shall consist of multiple, twisted pairs or triads (i.e. groups) of individually insulated and jacketed copper conductors with individual pair/triad shields (i.e. group shields) and an overall cable shield and jacket. Conductor insulation shall be rated 90°C in both wet and dry locations, and 600V. The jacket shall be PVC and resistant to abrasion, sunlight, and flame in accordance with UL 1277. Cable shall be UL 1277 Listed as NEC Type TC (Power and Control Tray Cable).

C. Cable and group shields shall consist of overlapped aluminum/polyester tape/foil providing 100% coverage. Instrumentation cables shall include an overall copper shield drain wire. Cables containing multiple twisted pairs or triads shall also include group shield drain wires.

D. Conductors, including drain wires, shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM B-8, with Class B stranding unless otherwise specified.

E. Instrumentation signal conductor size shall be no smaller than No. 16 AWG.

F. Instrumentation cable shall be Okoseal-N Type P-OS (for single pair or triad applications) or Okoseal-N Type SP-OS (for multiple pair or triad applications) as manufactured by the Okonite Company, Belden equivalent, or Southwire Company equivalent.

2.04 CONDUCTOR IDENTIFICATION

A. Conductors shall be identified using a color coding method. Color coding for individual power, control, lighting, and receptacle conductors shall be as follows:

1. 480/277V AC Power

    a. Phase A - BROWN

    b. Phase B - ORANGE

    c. Phase C - YELLOW

    d. Neutral – GREY

2. 120/208V or 120/240V AC Power

    a. Phase A - BLACK

    b. Phase B - RED

    c. Phase C - BLUE

    d. Neutral - WHITE

3. DC Power

    a. Positive Lead - RED

    b. Negative Lead - BLACK

4. DC Control

    a. All wiring - BLUE

5. 120 VAC Control

    a. 120 VAC control wire shall be RED except for a wire entering a motor control center compartment, motor controller, or control panel which is an interlock. This interlock conductor shall be color coded YELLOW. For the purposes of this Section, an interlock is defined as any wiring that brings voltage into the above mentioned equipment from a source outside that equipment.

6. 24 VAC Control

    a. All wiring - ORANGE

7. Equipment Grounding Conductor

    a. All wiring – GREEN

B. Individual conductors No. 2 AWG and smaller shall have factory color coded insulation. It is acceptable for individual conductors larger than No.2 AWG to be provided with factory color coded insulation as well, but it is not required. Individual conductors larger than No.2 AWG that are not provided with factory color coded insulation shall be identified by the use of colored tape in accordance with the requirements listed in Part 3 herein. Insulation colors and tape colors shall be in accordance with the color coding requirements listed above.

C. Conductors that are part of multi-conductor cable assemblies shall have black insulation. The conductor number shall be printed on each conductor's insulation in accordance with ICEA S-58-679, Method 4. Each conductor No.2 AWG and smaller within the cable assembly shall also be identified with a heat shrink tag with color coded background. Each conductor larger than No.2 AWG within the cable assembly shall also be identified by the use of colored tape. Heat shrink tags and colored tape shall be in accordance with the requirements listed in Part 3 herein. Tape color and heat shrink tag background color shall be in accordance with the color coding requirements listed above.

2.05 CABLE PULLING LUBRICANTS

A. Cable pulling lubricants shall be non-hardening type and approved for use on the type of cable installed. Lubricant shall be Yellow #77 Plus by Ideal, Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equal.

PART 3 -- EXECUTION

3.01 WIRE AND CABLE INSTALLATION

A. General

1. Wire and Cable shall be installed as specified herein and indicated on the Drawings. Unless specifically indicated otherwise on the Drawings, wire and cable shall be installed in separate raceways according to wiring type. For example, power wiring shall not be combined with control wiring, and control wiring shall not be combined with instrumentation wiring.

2. Wire shall be furnished and installed as single conductor cables, with limited exceptions. Multi-conductor cable assemblies shall only be installed where indicated on the Drawings, required by the NEC, or after obtaining written permission from the Engineer.

3. Where instrumentation cables are installed in control panels, motor controllers, and other locations, the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.

4. Instrumentation cable shielding shall be continuous and shall be grounded at one point only.

B. Splices

1. Splices shall not be allowed in power or control wire and cable unless approved in writing by the Engineer. If unique field conditions exist or pulling calculations indicate that splices may be required, the Contractor shall submit a detailed request indicating why splices are required to the Engineer. The Engineer shall be under no obligation to grant such request.

2. Splicing materials shall be barrel type butt splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equal. The use of screw-on wire connectors (wire nuts) shall only be permitted for lighting and receptacle circuits.

3. No splicing of instrumentation cable is permitted.

C. Wire and Cable Sizes

1. The sizes of wire and cable shall be as indicated on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop measured from source to load does not exceed 2-1/2%.

D. Additional Conductor Identification

1. In addition to the color coding identification requirements specified in Part 2 herein, individual conductors shall be provided with heat shrinkable identification tags. Identification tags for individual conductors shall have a white background where the conductor insulation is colored. Identification tags for individual conductors shall have a colored background where the conductor insulation is black. Background color shall match that of the taping provided on the individual black conductors.

2. Multi-conductor cables shall be provided with heat shrinkable identification tags in accordance with Part 2 herein.

3. All wiring shall be identified at each point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where a termination is made. The Contractor shall meet with the Owner and Engineer to come to an agreement regarding a wire identification system prior to installation of any wiring. Wire numbers shall not be duplicated.

4. Wire identification shall be by means of a heat shrinkable sleeve with appropriately colored background and black text. Wire sizes #14 AWG through #10 AWG shall have a minimum text size of 7 points. Wire sizes #8 AWG and larger shall have a minimum text size of 10 points. Sleeves shall be of appropriate length to fit the required text. The use of handwritten text for wire identification shall not be permitted.

5. Sleeves shall be suitable for the size of wire on which they are installed. Sleeves shall not be heat-shrunk onto control cables. Tags shall remain loose on cable to promote easier identification. For all other applications, sleeves shall be tightly affixed to the wire and shall not move. Sleeves shall be heat shrunk onto wiring with a heat gun approved for the application. Sleeves shall not be heated by any means which employs the use of an open flame. The Contractor shall take special care to ensure that the wiring insulation is not damaged during the heating process.

6. Sleeves shall be installed prior to the completion of the wiring terminations and shall be oriented so that they can be easily read.

7. Sleeves shall be polyolefin as manufactured by Brady, Seton, Panduit, or equal.

8. Wire identification in manholes, handholes, pull boxes, and other accessible components in the raceway system where the wiring is continuous (no terminations are made) shall be accomplished by means of a tag installed around the bundled group of individual conductors or around the outer conductor jacket of a multi-conductor cable. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all of the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that particular conduit number in the conduit and wire schedule. Minimum text size shall be 10 point. The tag shall be affixed to the wire bundle by the use of nylon wire ties, and shall be made of polyethylene as manufactured by Brady, Seton, Panduit, or equal.

9. Where colored tape is used to identify cables, it shall be wrapped around the cable with a 25% overlap and shall cover at least 2 inches of the cable.

E. Wiring Supplies

1. Rubber insulating tape shall be in accordance with ASTM D4388. Friction tape shall be in accordance with ASTM D69.

F. Training of Cable in Manholes, Handholes, and Vaults

1. The Contractor shall furnish all labor and material required to train cables around cable vaults, manholes, and handholes. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. The training shall be done in such a manner as to minimize chaffing.

2. Instrumentation cable shall be racked and bundled separate from AC wiring to maintain the required separation as follows:

a. 18 inches for 480/277 VAC wiring

b. 12 inches for 208/120 VAC wiring

c. 6 inches for 24 VAC wiring

G. Conductor Terminations

1. Where wires are terminated at equipment which requires lugs, connections shall be made by solderless mechanical lug, crimp type ferrule, or irreversible compression type lugs. Reference individual equipment specification sections as applicable for additional termination requirements.

2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make terminations impractical due to the size of the field wiring, the Contractor shall terminate field wiring in an adjacent junction box per the requirements of Section 16130 – Boxes, complete with terminal strips. Contractor shall install the smaller wiring from the device to the junction box in a conduit, using the terminal strip as the means for joining the two different wire sizes. Splicing of wires in lieu of using terminal strips is not acceptable.

3. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

4. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or equal.

5. All spare conductors shall be terminated on terminal blocks mounted within equipment or junction boxes. Unless otherwise noted, coiling up of spare conductors within enclosure is not acceptable.

H. Pulling Temperature

1. Cable shall not be installed when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less within a three (3) day period prior to pulling, the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the work day for which the cable is removed from the protected storage. Any cable reels with wire remaining on them shall be returned to storage at the completion of the workday.

3.02 FIBER OPTIC CABLE INSTALLATION

A. The Contractor shall install the fiber optic cable furnished by the General Contractor and/or the Instrumentation and Control Subcontractor. The cable shall be installed in its respective raceway system(s) as specified herein, indicated on the Drawings, and in accordance with the cable manufacturer's instructions. Reference Division 17 for additional information regarding the fiber optic cable.

3.03 TESTING

A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Shop Test

a. Wires and cables shall be tested in accordance with the applicable ICEA Standards. Wire and cable shall be physically and electrically tested in accordance with the manufacturer's standards.

2. Field Tests

a. After installation, all wires and cables shall be tested for continuity. Testing for continuity shall be "test light" or "buzzer" style.

b. After installation, some wires and cables shall be tested for insulation levels. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

i. For #8 AWG and larger 600V wire and cable, apply 1,000 VDC from a Megohmmeter for one (1) minute. Resistance shall be no less than 100 Megohms. Insulation testing is not required for power and control cables smaller than #8 AWG.

ii. Instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 Megohms or greater.

B. Wires and cables shall be tested after required terminations are made, but before being connected to any equipment.

C. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner. All conductors of a multi-phase circuit shall be replaced if one conductor fails the required testing. If part of a multi-set (parallel conductors per phase) circuit fails testing, only the set containing failure shall be replaced.

D. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment. Test reports shall be submitted to the Engineer.

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. ____

Date:			Company:				
Time:			Location:				
Circuit:	Circuit Length:	Aerial:	Duct:	Buried:	No. of Conductors	Size:	AWG MCM Shield:
Insulation Material:			Insulation Thickness:		Voltage Rating:		Age:
Type: _____Pothead _____Terminal					Location: Indoors_____ Outdoors_____		
Number and Type of Joints:							
Recent Operating History:							
Manufacturer:							
State if Potheads or Terminals were grounded during test:							
List associated equipment included in test:							
Miscellaneous Information:							

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. ____

Part Tested:	Test Performed: _____ Hours/Days: _____ After Shutdown: _____
Grounding Time:	Dry Bulb Temperature: _____ Wet Bulb Temperature: _____
Test Voltage:	Equipment Temperature: _____ How Obtained: _____ Relative Humidity: _____ Absolute Humidity: _____ Dew Point: _____

Megohmmeter: Serial Number: _____ Range: _____
Voltage: _____ Calibration Date: _____

Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground	Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground
1/4 Minute				5 Minutes			
1/2 Minute				6 Minutes			
3/4 Minute				7 Minutes			
1 Minute				8 Minutes			
2 Minutes				9 Minutes			
3 Minutes				10 Minutes			
4 Minutes				10/1 Minute Ratio			

Remarks:

- END OF SECTION -

SECTION 16130

BOXES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The scope of work under this Section includes furnishing and installing all pull boxes, junction boxes, and outlet boxes.

B. Requirements for other boxes and enclosures are not included in this Section. Reference each specific Division 16 equipment Section for requirements related to that equipment's respective enclosure.

C. Reference Section 16000, Basic Electrical Requirements, and Section 16111, Conduit.

1.02 CODES AND STANDARDS

A. Boxes shall be designed, manufactured, and/or listed to the following standards as applicable:

1. UL 514A - Metallic Outlet Boxes

2. UL 514C - Standard for Non-metallic Outlet Boxes, Flush Device Boxes, and Covers

3. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations

4. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations

5. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

6. NEMA 250 – Enclosures for Electrical Equipment

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:

1. Shop Drawings

B. Each submittal shall be identified by the applicable specification section.

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1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets for boxes, terminal strips, and all accessories

2. Overall bill of material for all boxes included under this Contract to summarize exactly what is being submitted for review. Bill of material shall at a minimum show each box type (i.e. pull, junction, or outlet), quantity, material of construction, dimensions, and proposed installation location.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

B. As-built drawings showing dimensions, internal box layout, terminal strip information, and terminal strip identification information shall be provided for all junction boxes. As-built drawings are not required for pull boxes or outlet boxes.

1.06 IDENTIFICATION

A. Each pull and junction box shall be identified with the box name as indicated on the Contract Drawings (e.g. PPB-1, CJB-1) or as directed by the Engineer. A nameplate shall be securely affixed in a conspicuous place on each box. Nameplates shall be as specified in Section 16195, Electrical – Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 PULL AND JUNCTION BOXES

A. General

1. All pull and junction boxes shall be UL listed and labeled.

2. Pull and junction boxes shall not be provided with eccentric or concentric knockouts.

3. Pull and junction boxes mounted embedded in concrete shall be UL listed for embedment.

4. Where metallic boxes are used they shall be of all welded construction. Tack welded boxes are not acceptable.

B. Pull Boxes

1. All pull boxes shall be provided with a matching gasketed cover. For covers with dimensions of 24 inches by 24 inches or less, the cover shall be held in place by machine screws. Other screw types are not acceptable. For covers with dimensions greater than 24 inches by 24 inches, the cover shall be hinged and held in place by screw-operated clamp mechanisms. Hinge pins shall be removable. Clamp mechanism material of construction shall match that of the associated box.

2. Pull boxes shall not have any wire terminations inside, other than those for grounding/bonding. A ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the pull box (minimum of two) shall be provided as spare terminations. Boxes requiring any other wire terminations shall be furnished and installed in accordance with the requirements for junction boxes herein.

3. Pull boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC.

4. Barriers shall be provided in pull boxes to isolate conductors of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:

a. Power wiring

b. AC control wiring

c. DC control wiring

d. Instrumentation wiring

C. Junction Boxes

1. Junction boxes used for lighting and receptacle circuits only shall be provided with a matching gasketed cover held in place by machine screws. Other screw types are not acceptable.

2. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with a hinged, gasketed cover. Hinge pins shall be removable. Cover shall be held in place by screw-operated clamp mechanisms. Clamp mechanism material of construction shall match that of the associated box.

3. Barriers shall be provided in junction boxes to isolate conductors and terminal blocks of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:

   a. Power wiring

   b. AC control wiring

   c. DC control wiring

   d. Instrumentation wiring

4. Junction boxes used for lighting and receptacle circuits only shall be allowed to have screw-on (wire nut) type connectors for wire terminations/junctions.

5. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with terminal strips, consisting the necessary number of screw type terminals. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected, with a 10A minimum capacity. Terminal strips shall be rated for the voltage of the circuits connected. A separate ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the junction box (minimum of two) shall be provided as spare terminations. When barriers are provided within the box, separate terminal strips shall be provided in each barrier area. Terminals shall be lettered and/or numbered to conform to the wiring labeling scheme in place on the project.

6. Junction boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC. Terminal blocks (including spare terminals) shall be considered when sizing the junction box.

D. Enclosure Types and Materials

1. In non-hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass or PVC
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2. In hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

AREA CLASSIFICATION	ENCLOSURE TYPE AND MATERIAL
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Type 304 Stainless Steel
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 4X, Type 304 Stainless Steel

3. Non-metallic enclosures, NEMA 7 enclosures, and NEMA 9 enclosures shall be provided with threaded integral conduit hubs.

2.03 OUTLET BOXES

A. General

1. Outlet boxes shall be provided with a trim appropriate for the wiring device installed inside. Reference Section 16141, Wiring Devices, for outlet box trim requirements. An appropriate outlet box trim is required to achieve the NEMA rating of the outlet boxes as specified herein.

B. Surface Mount Outlet Boxes

1. Outlet boxes shall be the deep type, no less than 2.5 inches deep.

2. Outlet boxes shall be provided in single or multi-gang configuration as required, sized in accordance with the requirements of the NEC.

3. In non-hazardous locations, outlet boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Cast Aluminum
Indoor Dry Process Area	NEMA 1, Cast Aluminum
Indoor Dry Non-process Area	NEMA 1, Cast Aluminum
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, PVC
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Cast Aluminum
All Outdoor Areas	NEMA 4X, Cast Aluminum

4. In hazardous locations, outlet boxes shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

AREA CLASSIFICATION	ENCLOSURE TYPE AND MATERIAL
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Cast Aluminum
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 4X, Cast Aluminum

5. Outlet boxes shall be provided with integral threaded conduit hubs mounted external to the box. Boxes with threaded conduit hubs mounted internal to the box or as a part of the box wall are not acceptable.

C. Flush Mount Outlet Boxes

1. Outlet boxes shall be no less than 2-1/8 inches deep, and 4-11/16 inches square. Boxes shall be UL listed and labeled. Pre-punched single diameter conduit knockouts are acceptable, however, concentric and eccentric knockouts are not acceptable.

2. Outlet boxes mounted flush in CMU walls shall be made of galvanized, tack welded steel, and suitable for installation in masonry walls. Sectional type boxes are not acceptable for this application.

3. Outlet boxes mounted flush in gypsum walls shall be made of galvanized pressed steel. Tack welded boxes are not acceptable for this application. Sectional type boxes are not acceptable for this application.

4. Outlet boxes mounted cast into concrete shall be concrete tight, and shall be made of galvanized steel or PVC.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Pull and Junction Boxes

1. Pull boxes and junction boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.

2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.

3. Box penetrations for conduits shall be made with a punch tool, and penetrations shall be of the size required for the conduit entry and/or hub. Oversized penetrations in boxes are not acceptable.

4. Watertight conduit hubs shall be provided for boxes where a NEMA 4X enclosure rating is specified. Reference Section 16111, Conduit, for conduit hub requirements.

5. Pull and junction boxes may be installed flush mounted in gypsum, concrete or CMU walls where appropriate provided that covers are easily removed or opened.

6. Pull and junction boxes shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

B. Outlet Boxes

1. Outlet boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.

2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.

3. Flush mounted outlet boxes shall be arranged and located so that tile and grout lines fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.

4. Outlet boxes shall be flush mounted in finished areas and other areas where practical. Flush mounted outlet boxes shall not be installed in hazardous areas and type 1 or 2 chemical storage/transfer areas.

5. For the below-named items, mounting heights from finished floor, or finished grade to top is applicable, depending on the type of wiring device to be installed in the outlet box. Mounting heights for outlet boxes shall be as follows, unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):

   a. Light switches, 48 inches

   b. Receptacles in indoor dry process/non-process areas, 16 inches

   c. Receptacles in indoor wet process areas and all indoor chemical storage/transfer areas, 48 inches

   d. Receptacles in outdoor locations, 24 inches

6. Outlet boxes shall be provided in the material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

- END OF SECTION -

SECTION 16141

WIRING DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install all switches, occupancy sensors, and receptacles of the type and at the locations as shown on the Drawings.

B. All switches and receptacles shall be furnished and installed in outlet boxes. Reference Section 16130, Boxes, for outlet box requirements.

C. Reference Section 16000, Basic Electrical Requirements, and Section 16123, Low Voltage Wire and Cable.

1.02 CODES AND STANDARDS

A. Wiring devices shall be designed, manufactured, and/or listed to the following standards as applicable:

1. UL 20 – General Use Snap Switches

2. UL 498 – Standard for Attachment Plugs and Receptacles

3. UL 943 – Ground Fault Circuit Interrupters

4. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

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C. Shop drawings shall include, but not be limited to:

1. Product data sheets.

1.05 IDENTIFICATION

A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The Contractor shall use the products of a single manufacturer for each type of wiring device.

C. The Contractor shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:

1. Where the selected plate manufacturer does not manufacture a suitable finish plate.

2. For heavy-duty receptacles rated at more than 30A.

3. Where non-standard plates are required, specified, or shown.

D. The Contractor shall furnish and install all wiring devices and device plates.

E. In non-hazardous areas, provide specification grade devices manufactured by Appleton, Crouse-Hinds, Leviton, Hubbell, Pass & Seymour, or Engineer approved equal.

F. In hazardous areas, provide devices manufactured by Appleton, Cooper Crouse-Hinds, Hubbell-Killark, or Engineer approved equal.

2.02 WIRING DEVICES

A. Wall switches for non-hazardous areas shall be rated for the current required to suit the application, but not less than 20A. Double pole, three-way, and four-way switches shall be provided where indicated on the Drawings, and as required. Switches shall be rated for 120-277VAC, and shall be UL 20 Listed.

B. Convenience receptacles for non-hazardous areas shall be rated for 20A at 125VAC. Convenience receptacles shall be UL 498 Listed. Tamper resistant receptacles are not acceptable.

C. Special purpose receptacles (welders, lab equipment, etc.) shall be provided with the proper NEMA configuration and ampacity as indicated on the Drawings. The coordinating plug for each special purpose receptacle shall be provided with the equipment which it is serving.

D. Ground fault circuit interrupter receptacles shall be rated for 20A at 125VAC. Ground fault circuit interrupter receptacles shall be UL 943 Listed. Tamper resistant receptacles are not acceptable.

E. Wall switches for hazardous areas shall be the factory sealed type, UL 1203 Listed for use in the hazardous area. Wall switches shall be rated for 120-277VAC, and shall be rated for the current required to suit the application, but not less than 20A

F. Receptacles for hazardous areas shall be rated 20A at 120-240VAC. Receptacles shall be UL 1203 listed for use in the hazardous area, utilizing delayed-action construction.

G. All wiring devices shall be approved for use with stranded conductors, if stranded conductors are to be used with the device. Reference Section 16123, Low Voltage Wire and Cable for conductor requirements

2.03 DEVICE PLATES

A. Device plates for indoor flush-mounted receptacles and switches shall be made of Type 304 stainless steel, not less than 0.032 of an inch thick, with beveled edges and milled on the rear so as to lie flat against the wall. Devices plates shall be provided with a gasket.

B. Device plates for outdoor installations, indoor wet process areas, and chemical storage/transfer areas shall be Appleton Type FSK, Crouse-Hinds #DS185, or equal for wall switches. Device plates for receptacles shall be “in-use” style. “In-use” weatherproof covers shall be rugged, minimum 3 ¼” depth, die-cast aluminum as manufactured by Thomas & Betts "Red Dot," Intermatic International, Inc., or equal.

C. Device plates for indoor dry process and non-process areas with surface mounted boxes shall be Crouse-Hinds DS32, or equal for switches, and Crouse-Hinds DS23 or equal for receptacles.

2.04 PLUGS

A. The Contractor shall furnish suitable plugs with equipment furnished under the respective specification Section. Plugs shall be black rubber or plastic. For waterproof receptacles, the plugs shall be similar in construction to the receptacles and shall be encased in corrosion resistant yellow housing provided with clamping nuts and stuffing gland cable outlets.

2.05 PROCESS INSTRUMENTS

A. The Contractor shall furnish and install a local disconnect switch at each process instrument (e.g., level transmitter, flow transmitter, analytical instrument etc.,) to disconnect the 120VAC power supply to the instrument. The device shall be a NSSC series manual motor starting switch without overload protection as manufactured by Crouse-Hinds, Appleton equivalent, or equal. For hazardous locations, the device shall be UL 1203 Listed.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Where more than one (1) switch occurs at one (1) location, gang plates shall be used.

B. All device plates shall be set true and plumb, and shall fit tightly against the finished wall surfaces and outlet boxes.

C. Wiring device box (outlet box) mounting heights shall be as specified in Section 16130, Boxes.

D. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the Contractor shall bring it to the attention of the Engineer for a decision.

E. All receptacles shall have a self-adhesive label installed on the top at the respective device plate that indicates which panel and which circuit number the receptacle is supplied from. Labels shall have a white background and black lettering in 14 point font.

3.02 CIRCUITING

A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience receptacles are permitted per 20A, 120V circuit, unless otherwise indicated on the Drawings.

- END OF SECTION -

SECTION 16170

GROUNDING AND BONDING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered a minimum requirement for compliance with this Specification.

B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100. Conflicts shall be promptly brought to the attention of the Engineer.

C. In addition to the NEC requirements, building structural steel columns shall be permanently and effectively grounded:

D. Reference Section 16000, Basic Electrical Requirements

1.02 CODES AND STANDARDS

A. Equipment and materials covered under this Section shall be designed, manufactured, and/or listed to the following standards as applicable:

1. UL 467 – Grounding and Bonding Equipment

2. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

3. IEEE 1100 – Recommended Practice for Power and Grounding Electronic Equipment

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Reports of certified field tests.

B. Each submittal shall be identified by the applicable specification section.

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1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Drawings and written description of how the Contractor intends to furnish and install the grounding system.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 GROUND RODS AND GRID

A. Ground rods shall be rolled to a commercially round shape from a welded copper-clad steel manufactured by the molten-welding process or by the electro-formed process (molecularly bonded). They shall have an ultimate tensile strength of 75,000 pounds per square inch (psi) and an elastic limit of 49,000 psi. The rods shall be not less than 3/4 inch in diameter by 10 feet in length; and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of 0.010 inch at any point on the rod. Ground rods shall be UL 467 listed. The ground rods shall be manufactured by Erico Products, Blackburn, or equal.

B. Except where specifically indicated otherwise, all exposed non current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be grounded.

C. The ground connection shall be made at the main service equipment and shall be extended to the ground grid surrounding the structure. The ground grid shall also be connected to the point of entrance of the metallic water service. Connection to the water pipe shall be made by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, connection shall be made with the lug bolted to the street side of the flanged connection.

D. Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

2.03 FITTINGS

A. Grounding connections to equipment shall be bolted. Cable end connections shall be made by hydraulic crimp or exothermically welded. Split bolt type connectors are not acceptable. Fittings shall be UL 467 listed.

2.04 EQUIPMENT GROUNDING CONDUCTORS

A. An insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Insulation shall be of the same type as the ungrounded conductors in the raceway and shall be green in color. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

2.05 EQUIPMENT GROUNDS

A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

B. For all control panels, disconnect switches, and other electrical enclosures, equipment grounds and bonding jumpers shall be terminated individually on a ground bar or mechanical lugs. No wire nuts will be permitted.

2.06 EXOTHERMIC WELDS

A. All exothermic welding shall be completed per welding kit manufacturer's instructions. Exothermic welds shall be CadWeld by Erico or ThermoWeld.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.

B. Ground Grid

1. A main ground grid shall be provided for each structure and interconnecting structure grids consisting of driven ground rods as shown on the Drawings. Ground rods shall be driven straight down into the earth, or if objects are encountered, at an angle to avoid the obstruction.

2. The ground rods shall be interconnected by the use of copper cable exothermically welded to the rods. The grounding cables shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtails" shall be connected to the ground grid and shall enter the buildings and structure from the outside and shall be connected to steel structures, and equipment as described in this Section and as required to provide a complete grounding system. The copper pigtails shall be exothermically welded to the ground grid, and connected to building reinforcement steel by hydraulic crimp.

3. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.

4. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.

5. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.

6. Buried exothermic welds and ground ring shall not be backfilled until inspected by Engineer.

C. Raceways

1. Conduit which enters equipment such as switchgear, motor control centers, transformers, panelboards, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

a. None required.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

b. Fall of potential tests shall be performed on the ground grid per IEEE81 recommendations by a third party, independent testing firm. A fall of potential plot shall be submitted at the conclusion of testing for Engineer review. Documentation indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made shall be submitted. Testing shall show that the ground grid has 5 ohms resistance or less. Due to soil conditions and/or unforeseen field conditions, ground resistances greater than 5 ohms may be acceptable if specifically approved in writing by the Engineer. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground grid under test isolated from other grounds.

c. Continuity tests for the grounding electrode conductor shall be performed. Test will be accepted when a resistance of less than 1 ohm is shown for this conductor.

- END OF SECTION -

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SECTION 16190

SUPPORTING DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install structural supports for mounting and installing all conduit, electrical equipment, lighting, alarm systems, instrumentation, and communications equipment furnished under this Contract.

B. Equipment shall be installed strictly in accordance with recommendations of the manufacturer and best practices of the trade resulting in a complete, operable, and safe installation. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation.

C. Reference Section 16000, Basic Electrical Requirements.

1.02 CODES AND STANDARDS

A. Equipment and materials covered under this Section shall be designed, manufactured, and/or listed to the following standards as applicable:

1. ASTM A123 – Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.

2. ASTM A153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.

3. ASTM A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

4. ASTM A276 – Standard Specification for Steel Bars and Shapes

5. ASTM B783 – Standard Specification for Materials for Ferrous Powder Metallurgy Structural Parts

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop drawings

2. Structural support calculations (if required)

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B. Each submittal shall be identified by the applicable Specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

A. Support channel shall be 1-5/8” by 1-5/8” minimum, with 12 gage material thickness.

B. Support channel, support channel fittings, and threaded rod shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	**MATERIAL OF CONSTRUCTION**
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Hot Dipped Galvanized Steel
Indoor Dry Non-process Area	Hot Dipped Galvanized Steel
Indoor Type 1 Chemical Storage/Transfer Area	Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

C. Fastening hardware (bolts, nuts, washers, and screws) shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	MATERIAL OF CONSTRUCTION
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Type 304 Stainless Steel
Indoor Dry Non-process Area	Type 304 Stainless Steel
Indoor Type 1 Chemical Storage/Transfer Area	Fiberglass
Indoor Type 2 Chemical Storage/Transfer Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Concrete or Masonry Inserts

1. The Contractor shall be responsible for the furnishing and installation of all anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.

2. If a time delay for the arrival of any special inserts or equipment drawings, etc. occurs, the Contractor may, if permitted by the Engineer, make arrangements for providing approved recesses and openings in the concrete or masonry and, upon subsequent installation, the Contractor shall be responsible for filling in such recesses and openings. Any additional costs that may be incurred by this procedure shall be borne by the Contractor.

3. The Contractor shall furnish leveling channels for all switchgear, switchboards, motor control centers, and similar floor mounted equipment. The leveling channels shall be provided for embedment in the equipment housekeeping pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain concrete coverage of the reinforcement bars while not causing associated equipment to exceed the maximum mounting height requirements of the NEC.

B. Support Fastening and Locations

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel.

2. All holes made in reflected ceilings for support rods, conduits, and other equipment shall be made adjacent to ceiling grid bars where possible, to facilitate removal of ceiling panels.

3. Support channel shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.

4. All equipment, devices, and raceways that are installed on the dry side of a water bearing wall shall not be installed directly onto the wall. Support channel shall be used to allow ventilation air to pass behind the equipment, devices, or raceway.

5. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework.

6. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.

7. Actual designs for supporting framework should take the nature of a picture frame of support channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; he shall submit design details to the Engineer for acceptance before proceeding with the fabrication.

8. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

9. For all installations where fiberglass supporting materials are required, the Contractor shall submit structural calculations and the details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the State of South Carolina.

10. For the following installations where conduits are provided with a support system suspended from the above or attached to a vertical structure, the Contractor shall submit structural calculations and details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the State of South Carolina.

    a. A quantity of twelve (12) or more conduits trade size 1” and smaller are proposed for a conduit support rack.

    b. A quantity of eight (8) or more conduits trade sizes 1 ½” to 2 1/2” are proposed for a conduit support rack.

    c. A quantity of four (4) or more conduits trade sizes 3” and larger are proposed for a conduit support rack.

11. Single conduits installed exposed along walls and ceilings shall be secured to the wall or ceiling with a one-hole conduit clamp and clamp-back. Where multiple conduits are installed exposed together, support channel and conduit clamps shall be used.

- END OF SECTION -

SECTION 16195

ELECTRICAL - IDENTIFICATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All switchgear, switchboards, motor control centers, variable frequency drives, lighting and distribution panelboards, combination starters, control panels, pull and junction boxes, enclosures, disconnect switches, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.

B. The types of electrical identification specified in this section include, but are not limited to, the following:

1. Operational instructions and warnings.

2. Danger signs.

3. Equipment/system identification signs.

4. Nameplates.

1.02 SIGNS

A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.

1.03 LETTERING AND GRAPHICS

A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

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1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

2.02 NAMEPLATES

A. Nameplates shall be engraved, high pressure plastic laminate, white with black lettering.

B. Nameplates shall be attached to NEMA 4X enclosures utilizing UL-recognized mounting kits designed to maintain the overall UL Type rating of the enclosure. Mounting kit fasteners shall be stainless steel Type AHK10324X as manufactured by Hoffman, or equal.

2.03 HIGH VOLTAGE SIGNS

A. Standard "DANGER" signs shall be of baked enamel finish on 20 gage steel; of standard red, black and white graphics; 14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate identification.

2.04 CONDUIT IDENTIFICATION

A. Conduit identification shall be as specified in Section 16111, Conduit.

2.05 WIRE AND CABLE IDENTIFICATION

A. Field installed wire and cable identification shall be as specified in Section 16123, Low Voltage Wire and Cable and Section 16121, Medium Voltage Cable.

B. A plastic laminate nameplate shall be provided at each panelboard, motor control center, switchgear assembly, and switchboard assembly. This nameplate shall be used to clearly convey the conductor identification means used at that piece of equipment (i.e. Phase A=Brown, Phase B=Orange, C = Yellow).

C. Wiring identification for factory installed wiring in equipment enclosures shall be as specified in the respective section.

2.06 BOX IDENTIFICATION

A. Pull, junction and device box identification shall be as specified in Section 16130 – Boxes.

PART 3 -- EXECUTION

3.01 NAMEPLATES

A. Nameplates shall be attached to the equipment enclosures with (2) two stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives is not permitted.

3.02 OPERATIONAL IDENTIFICATION AND WARNINGS

A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

3.03 POWER SOURCE IDENTIFICATION

A. After installation of all field equipment (i.e. valves, motors, fans, unit heaters, instruments, etc) install nameplates at each power termination for the field equipment. Nameplate data shall include equipment designation (tag number), power source (MCC number, panelboard, etc), circuit number, conduit number from schedule and voltage/phase.

B. Contractor to coordinate with the Engineer and the Owner regarding exact nameplate placement during construction.

C. Nameplates shall be as specified herein.

- END OF SECTION -

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SECTION 16322

MEDIUM VOLTAGE TRANSFORMERS - LIQUID FILLED PAD-MOUNT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, and test liquid filled, pad-mount transformers for power distribution systems as specified herein, as indicated on the Drawings, and as required to complete the electrical installations. It should be noted that both step-up and step-down transformer applications are present in this project, and transformer types and styles should be provided as indicated on the Drawings.

B. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

C. Reference Section 16000, Basic Electrical Requirements.

1.02 CODES AND STANDARDS

A. The liquid filled pad-mount transformer shall comply with the following codes and standards:

1. American National Standards Institute (ANSI):

a. ANSI C57.12.00-Latest Revision, General Requirements for Liquid Immersed Distribution, Power, and Regulating Transformers.

b. ANSI C57.12.28-Latest Revision, Switchgear and Transformers, Padmounted Equipment - Enclosure Integrity.

c. ANSI C57.12.26-Latest Revision, Standard for Transformers, Padmounted, Compartmental Type, Self Cooled Three Phase Distribution Transformer for Use with Separable Insulated High Voltage Connectors, High Voltage 34,500 Grd./y 19,920 Volts and Below: 2500 kVA and Smaller.

d. ANSI C57.12.90-Latest Revision, Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers and Guide for Short Circuit Testing of Distribution and Power Transformers.

e. ANSI/IEEE 386-1985, Separable Insulated Connectors for Power Distribution Systems Above 600 Volts.

2. Institute of Electrical and Electronic Engineers (IEEE)

3. National Electrical Code (NEC)

4. National Electrical Manufacturers Association (NEMA)

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a. NEMA 210

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts List

4. Special Tools List

5. Reports of Certified Shop Tests

6. Reports of Field Tests including Oil Analysis

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Sample equipment nameplate diagram.

3. Drawings showing clearly marked overall dimensions for each transformer. Drawings shall show conduit stub-up area locations.

4. Weight of each transformer.

5. Proof of ISO 9001 registration.

6. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g. TX-3).

E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The transformers shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

The Contractor shall furnish the following minimum spare parts for each transformer.

No. Required	Description
1 set	Primary fuses of each size provided.

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.

D. Spare parts lists, included with the Shop Drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.07 IDENTIFICATION

A. Each transformer shall be identified with the identification number indicated on the Drawings (e.g. TX-3). A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. All transformer manufacturers shall be registered as an ISO 9001 quality manufacturer.

C. Liquid filled pad-mount transformers shall be by the Square D Company, Eaton, ABB, or equal.

2.02 PAD-MOUNT TRANSFORMERS

A. Pad-mount transformers shall be of a compact design. The transformer kVA rating shall be as indicated on the Drawings. All units shall be a pad mounted compartmental type, which when assembled shall be an integral unit for mounting on a pad. All units shall be designed to comply with the short circuit capability requirements of ANSI C57.12.00.

B. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 55 degrees C rise, based on an average ambient of 30 degrees C over 24 hours with a maximum of 40 degrees C. The insulation system shall allow an additional 12% kVA output at 65 degrees C average winding temperature rise by resistance, on a continuous basis, without any decrease in normal transformer life, as defined by ANSI C57.12.00. Primary bushings shall be rated 200 or 600 amperes as required for each specific transformer capacity.

C. Coolant and insulating fluid shall be less flammable/high fire point as defined per the NEC. The transformer shall be furnished and installed in accordance with the latest edition of Article 450 of the NEC and in accordance with the requirements of the testing and listing agency of the liquid. All transformer liquid shall be bulk tested for polychlorinated biphenyls (PCBs) per ASTM D 4059 and certified, upon request, as having no detectable level of PCB.

D. The high voltage windings shall be rated 24.9 kV and 125 or 150 kV BIL unless indicated otherwise on the Drawings, for use on a solidly grounded system and shall have two (2) 2-1/2% full capacity taps above and below rated voltage.

Impedance of the transformers shall be 5.75% subject to NEMA/ANSI ± 7.5% impedance tolerance unless otherwise indicated on the Drawings.

E. The low voltage windings for the step-down transformers shall be rated 480Y/277 VAC and 30 kV BIL unless indicated otherwise on the Drawings. The low voltage windings for the step-up transformers shall be rated 4160Y/2400 VAC and 60 kV BIL unless indicated otherwise on the Drawings. Transformers shall be designed for step up or down use, as indicated on the Drawings.

F. Low voltage neutrals shall be connected internally to the secondary neutral lugs and brought out to an insulated low voltage neutral spade type bushing with an externally removable ground strap. The low voltage neutral shall be a fully insulating bushing. A ground pad shall be provided on the outer surface of the tank with one or more removable ground straps suitably sized for the short circuit rating of the transformer provided and connected between the neutral bushing and the ground pad.

G. High and low voltage windings shall be copper.

H. The transformer and associated terminal compartments shall be so designed and constructed as to be tamper resistant. There shall be no screws, bolts, or other fastening devices which are externally removable. Transformers shall be suitable for outdoor installation without a fence or other area enclosure. Full height, air filled incoming and outgoing terminal compartments with hinged doors shall be located side by side separated by a steel barrier, with the incoming (primary) compartment on the left. The lift-off doors shall be equipped with stainless steel hinges to allow the doors to be removed and door stops to hold the doors open if not removed while working in the compartments. The incoming compartment shall be accessible only after the door to the outgoing (secondary) compartment has been opened. To facilitate making connections and permit cable pulling, the doors shall be removable. Removable door sill on compartments shall be provided to permit rolling or skidding of unit into place over conduit "stub-ups" in foundation.

Locking provisions shall be provided in accordance with Paragraph 7 of ANSI C57.12.26-Latest Revision utilizing a captive penta-head bolt. Enclosure security shall conform with Paragraph 4 of ANSI C57.12.20-Latest Revision.

I. The high voltage incoming line compartment shall be dead-front, shall enclose the high voltage bushings, and provide for cabling from below. Externally clamped dead-front primary bushings shall be universal bushing wells with dead front inserts or dead front, "feed thru" inserts as required. The compartment shall have a hinged door with a fastening device which is accessible only through the low voltage compartment and makes possible the use of a single padlock.

The Contractor shall furnish dead front, elbow cable terminators. Elbow terminators shall be load-break at sizes less than 600A.

J. Furnish a load break, gang operated, liquid immersed switch that is externally operable from the high voltage compartment through the use of a distribution hot-stick. Switch shall be the 2-position "OFF-ON" type for use on a radial feed system Liquid-immersed switch shall be carry ampere rating as required for the application.

K. Primary fusing shall be provided with an oil immersed drawout expulsion BAY-O-NET Dual Sensing type Fuse in series with an ELSP type current limiting backup fuse designed to protect the transformer in the event of secondary or internal faults, or overload conditions. The BAY-O-NET fuse shall be replaceable and hook stick operable.

L. 35kV distribution class lightning arresters for surge protection shall be provided. For radial feed systems, three (3) arresters shall be provided. Arresters shall be mounted in the high voltage compartment. Surge arrester rating shall be per the IEEE C62.22.

M. The low voltage incoming line compartment shall be live-front, shall be arranged for cabling from below, and shall contain 3-spade type externally clamped bushings for phase connections and 1-spade type bushing for neutral and/or ground connection. Low voltage bushings shall be supported with an insulating material in a manner designed to counteract any downward forces resulting from the connection of multiple cables to the bushings. Spades shall be the appropriate length to support the number of cables to be terminated as shown on the Drawings with standard NEMA hole spacing. The low voltage door shall have a 3-point latch (top, bottom, middle) to discourage unauthorized entry.

N. The transformer shall be designed to be capable of withstanding short circuits without damage on any winding, at a magnitude of fault current equal to the full rated voltage divided by the per unit impedance with full voltage maintained on all windings connected to the external source of power.

O. The internal high-voltage leads of the transformer shall be adequately insulated and mechanically secured. Connection to the coil conductors shall be made by a process ensuring avoidance of damage to the coil insulation.

P. All high-voltage phase leads shall be installed rigidly and spaced to provide dielectric and mechanical strength and ensure absolute phase isolation.

Q. All high and low voltage windings shall be secured in place by use of B-stage epoxy pattern paper. The epoxy shall be thermally cured under pressure to ensure the bonding of conductor and paper.

R. Core laminations shall be annealed, free of burrs, and furnished with a heat-resistant insulating coating. All core sections shall be grounded to the core clamp.

S. Bolted connections will be acceptable only from lead to bushing connection. All other connections shall be welded or adequately crimped.

T. The transformer shall be of sealed-tank construction or sufficient strength to withstand a pressure of 7 psi without permanent distortion. The domed cover to aid water run-off shall be welded and the fastenings tamperproof. The transformer shall remain effectively sealed for a top liquid temperature range of -30°C to 105°C. When required, cooling panels shall be provided on the back and sides of the tank.

U. Lifting provisions shall be permanently attached and arranged on the tank to provide a distributed, balanced lift in a vertical direction for the completely assembled transformer.

V. Terminal designations shall be as defined by ANSI C57.12.70. The high and low voltage terminal designations shall be indicated on the tank wall with oil resistant yellow paint or decals. A permanently marked diagrammatic instruction nameplate shall be located inside the low voltage compartment and be in accordance with all provisions contained in ANSI C57.12.26, Paragraph 7.4.

W. The inside base of the transformer sill shall have a flange for anchoring the cabinet to the equipment pad.

X. Tank grounding provisions shall be as stated in ANSI standards. The grounding provisions shall be capped before painting the unit. The unit shall be shipped with the caps in place.

Y. The transformer shall be equipped with an externally operated, padlockable tap changer. The tap changer shall be designed for de-energized operation. The operating handle shall give permanent visual indication of the voltage position and have a provision for securing it at the desired position. The tap changer shall be marked for de-energized operation and the handle shall be easily accessible and located inside the high-voltage compartment. By operating the handle, all three phases shall be operated simultaneously. Tap position shall be clearly marked and a locking mechanism provided to prevent accidental operation.

Z. Furnish each transformer with the following accessories:

1. A liquid level indicator.

2. A dial type liquid temperature gauge.

3. An oil drain valve located in the primary compartment with a built-in sampling device.

4. A 1-inch NPT upper plug (or cap) for filling and pressure testing.

5. A pressure vacuum gauge.

6. A pressure relief valve.

7. An automatic pressure relief device (self resealing w/indicator).

8. A key-interlock to high voltage door.

9. Alarm contacts for accessory gauges.

10. Hot stick for operating internal switches and pulling fuses.

AA. All transformers shall be coated with a primer and finish coat to provide a tough, non-chalking weather resistant finish. The finish coat shall be dark green Munsell-7.5G.Y.3.29.1.5 (Olive Green). The paint thickness shall be a minimum of 2.5 mils.

AB. The transformers shall be provided with the following labels, designed for outside

application, permanently affixed to the front of each unit.

1. kVA Rating label

   (Shall be centered 4-6 inches above the Secondary Voltage decal).

2. Secondary Voltage label

   (Shall be centered 4-6 inches above the Danger Hazardous Voltage decal)

3. Danger Hazardous Voltage decal

   (Shall be centered on the inside of the high voltage compartment door)

4. “Non-PCB's" label in conformance with EPA 40 CFR Part 761

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The transformers shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer.

B. Prior to final completion of the work, all metal surfaces of the transformer shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

C. Adjust primary taps such that the secondary voltage is within two (2) percent of rated voltage.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. None required.

2. Certified Shop Tests and Reports

   a. Submit description of proposed testing methods, procedures, and apparatus.

   b. Submit notarized and certified copies of all test reports.

   c. The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards. Temperature rises may be certified from basic design. The tests shall be:

i. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating.

ii. Ratio tests on the rated voltage connection and on all tap connections.

iii. Polarity and phase-relation tests on the rated voltage connections.

iv. No-load loss at rated voltage on the rated voltage connection.

v. Exciting current at rated voltage on the rated voltage connection.

vi. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating.

vii. Applied potential test.

viii. Induced potential tests.

3. Field Tests

a. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition. All visual and mechanical inspections shall be performed. All electrical tests shall be performed, including optional tests.

b. Upon energization of each transformer, the Contractor shall take a sample of the transformer insulating liquid in accordance with ASTM D-923 to be analyzed and establish a baseline for future analysis. Analysis shall be performed by an independent testing laboratory that regularly engages in transformer insulating liquid testing. A report of the findings shall be submitted to the Engineer and Owner. The sample shall be tested for the following (minimum):

i. Dielectric breakdown voltage per ASTM D-877 and/or ASTM D-1816.

ii. Acid neutralization number per ASTM D-974

iii. Specific gravity per ASTM D-1298

iv Interfacial tension per ASTM D-971 or ASTM D-2285

v. Color per ASTM D-1500

vi. Visual condition per ASTM D-1524

vii. For all silicone filled units and all units with a voltage class of 25kV or greater, test for water in insulating liquid per ASTM D-1533

viii. Measure dissipation factor or liquid power factor per ASTM D-924

ix. Perform dissolved gas analysis per ANSI/IEEE C57.104 or ASTM D-3612.

- END OF SECTION -

SECTION 16345

MEDIUM VOLTAGE VACUUM CIRCUIT BREAKER SWITCHGEAR - 27 KILOVOLT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation, dead-front type, medium voltage, draw-out, metal-clad circuit breaker switchgear as specified herein and indicated on the Drawings.

B. It is the intent under this Contract to require the generator manufacturer to provide a complete standby power system including, but not limited to, the Medium Voltage Vacuum Circuit Breaker Switchgear specified within this Section. It is also the intent under this Contract for all items specified within this section to be included in a pre-fabricated electrical equipment building, sized to accommodate all components for the system. Refer to Specification Section 16620 and 16800 for further details.

C. The switchgear shall be the vacuum power circuit breaker type with drawout circuit breaker elements.

D. The line-up shall contain a main circuit breaker, a tie circuit breaker, generator circuit breaker, feeder circuit breakers, metering equipment, protective relays, control devices, and all accessories as specified herein, indicated on the Drawings, and as required to result in a complete and operable power distribution equipment assembly.

E. The Contractor shall obtain the switchgear from one manufacturer who shall also manufacture the structure and major equipment components, which includes, but is not limited to, assemblies of circuit breakers and auxiliary housings, drawout type vacuum circuit breakers, meters, and controls. Sub-contracting of wiring is not acceptable.

F. The switchgear shall be assembled using ANSI, and where applicable, NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

G. Circuit breaker control and relaying/metering circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings.

H. It is the intent under this Contract that the engine-generator set provided as part of this project shall be paralleled with the electrical utility via the switchgear lineup specified herein. The Contractor will be responsible for providing all necessary controls, components, and interconnections between the generator and utility to accomplish successful parallel operation and closed-transitioning operations. **The contractor is responsible for obtaining (in writing) proof of operations from the Engineer and Owner, prior to the project receiving Substantial Completion.**

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1.02 CODES AND STANDARDS

A. The switchgear assemblies and power circuit breakers shall comply with the following codes and standards:

1. American National Standards Institute (ANSI):

a. C37.06 - Switchgear Rating Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

b. C37.09, Section 4 - Test Procedures for AC High Voltage Circuit Breakers.

c. C37.20.2, Section 5.2 - Metal-Clad and Station Type Cubical Switchgear.

d. C39.1 - Requirements for Electrical Analog Indicating Instruments.

e. C57.13 - Requirements for Instrumentation Transformers.

f. C37.20.3 - Metal-Enclosed Interrupter Switchgear

g. C37.22 - Preferred Ratings and Related Required Capabilities for Ac Medium-Voltage Switches Used in Metal-Enclosed Switchgear

h. C37.57 - Metal-Enclosed Interrupter Switchgear Assemblies-Conformance Testing

i. C37.58 - Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear-Conformance Test Procedures

2. Institute of Electrical and Electronic Engineers (IEEE).

3. National Electrical Code (NEC).

4. National Electrical Manufacturers' Association (NEMA):

a. SG4 - Power Circuit Breakers

b. SG5 - Power Switchgear Assemblies.

1.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Shop Tests

   a. The switchgear specified in this Section shall be shop tested and inspected in accordance with the equipment manufacturer's standard procedures. The testing and inspection procedures shall demonstrate that the equipment tested conforms to the requirements specified and shall be approved by the Engineer. All tests shall be in accordance with the latest version of ANSI and NEMA standards. At least 10 days notice shall be given the Engineer prior to such tests and inspection dates.

2. Certified Shop Tests and Reports

   a. Submit description of proposed testing methods, procedures, and apparatus.

   b. Submit certified copies of all factory test reports.

   c. As a minimum, the entire switchgear assembly shall go through a quality inspection before shipment. This inspection shall include, but is not limited to, the following:

      i. Physical inspection of the structure and the electrical conductors including bussing, general wiring, and cells.

      ii. General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.

      iii. AC dielectric tests of the power circuits and control circuits.

      iv. Markings/labels, including instructional type, Underwriters Laboratory (U.L.), and inspector's stamps.

   d. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI standards.

      i. Alignment test with master cell to verify all interfaces and interchangeability.

      ii. Circuit breakers operated over the range of minimum to maximum control voltage.

      iii. Factory setting of contact gap.

      iv. One-minute dielectric test per ANSI standards.

      v. Final inspections and quality checks.

   e. The following production test shall be performed on each breaker housing.

i. Alignment test with master breaker to verify interfaces.

ii. One-minute dielectric test per ANSI standards on primary and secondary circuits.

iii. Operation of wiring, relays, and other devices verified by an operational sequence test.

iv. Final inspection and quality check.

f. The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the switchgear.

3. Field Tests

a. Field tests shall be performed in accordance with requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts List

4. Special Tools List

5. Proposed Testing Methods and Reports of Certified Shop Tests

6. Manufacturer's field start-up report.

7. Manufacturer's representative's certification.

B. Each submittal shall be identified by the applicable specification section.

1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submissions will be returned to the Contractor without review for resubmittal.

C. Shop drawings for <u>each switchgear assembly</u> shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all electrical ratings.

2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

3. Weights of all component parts, assembled weight of units, and approximate total shipping weight.

4. Example equipment nameplate data sheet.

5. Plan, front and side view drawings, including overall dimensions of each switchgear assembly. Identify shipping splits and show conduit entry/exit locations on the drawings.

6. Internal wiring diagram of each medium voltage switchgear cell. Each wiring diagram shall include wire identification and terminal numbers. Internal wiring diagrams of each low voltage metering compartment including wire identification and terminal numbers.

7. Internal cell-to-cell interconnection wiring diagrams including wiring identification and terminal numbers.

8. Complete one-line diagram of each switchgear line-up and complete three line diagrams for each switchgear cell. These drawings shall indicate devices comprising the switchgear assembly including, but not limited to, circuit breakers, control power and instrument transformers, meters, relays, and control devices. Clearly indicate the electrical ratings of all devices.

9. Bill of material list for each switchgear assembly including each switchgear cell.

10. Nameplate schedule for each cell.

11. Manufacturer's installation instructions.

12. Manufacturer's standard warranty.

13. Cable terminal sizes.

14. DC battery system sizing calculations.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.06 OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books, descriptive bulletins, technical bulletins, application data booklets and other applicable instructional information.

2. Recommended spare parts list.

3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process.

1.07 TOOLS, SUPPLIES, AND SPARE PARTS

A. The switchgear shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment and all spare parts as recommended by the equipment manufacturer.

The Contractor shall furnish the following minimum spare parts for each switchgear assembly:

No. Required	Description
1 set	Power and control fuses of each size provided
1	Control power transformer of each size provided
5	Lamps and lenses for indicating lights, each color
1	PLC Power Supply
1	PLC I/O module for each type used

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the Work, at which time they shall be delivered to the Owner.

D. Spare parts lists, included with the shop drawing submittal shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.08 IDENTIFICATION

A. Each switchgear assembly shall be identified with the identification number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each switchgear assembly. Nameplates shall be as specified in Section 16195, Electrical - Identification.

1.09 TRAINING

A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory-trained representative(s) who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be in accordance with the requirements of Section 11000, Equipment - General Provisions.

1.10 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications for construction sequencing information during the construction period.

1.09 WARRANTY TERMS

A. The Contractor and manufacturer's warranty shall in no event be for a period of less than five (5) years from date of Permit to Operate and shall include repair labor, travel expense necessary for repairs at the jobsite, and expendables used during the course of repair. Submittals received without written warranties as specified shall be rejected in their entirety.

B. The Contractor shall provide a complete warranty covering all equipment included in the scope of supply. This warranty shall include, but is not limited to, the following:

- All paralleling and transfer controls
- Complete switchgear lineup, including all components and accessories
- Pre-engineered electrical building
- DC battery system and charger

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. It is the intent of these specifications that the switchgear be produced by a single manufacturer who shall be responsible for matching all components and providing equipment which functions together as a system. Manufacturers that provide complete

switchgear assemblies using vacuum power circuit breakers produced by another major manufacturer shall only be allowed if specifically accepted by the Engineer.

C. The switchgear shall be VacClad-W as manufactured by Eaton, PV System 27 as manufactured by Powell Electrical Manufacturing Company, or Engineer Approved Equal.

D. The switchgear/generator paralleling controls system integrator shall be Caterpillar Switchgear (formerly Caterpillar ISO) or their preferred integrator. The switchgear, generator, and controls associated with the system shall be provided by Caterpillar as delineated herein and in Specification Section 16620.

2.02 MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

A. General

1. Switchgear shall be suitable for use as service entrance equipment.

2. The switchgear described in this specification shall be designed for operation on a 23.9 kV, three-phase, three-wire, solidly grounded 60 hertz system.

B. Ratings

1. Nominal voltage rating shall be as indicated on the Drawings. The entire assembly shall be suitable for 27 kV maximum AC service. Basic impulse insulation level (BIL) shall be 125 kV.

2. Rate complete switchgear assembly to withstand mechanical forces exerted during short circuit conditions when connected directly to a power source having available fault duty of 16,000 amperes.

3. The main bus shall have an ampere rating as indicated on the Drawings.

4. All ratings shall be tested to the requirements of ANSI C37.04, C37.06, C37.09 and C37.20.2.

5. The switchgear assembly shall be suitable and rated for indoor construction within a prefabricated metal electrical building.

C. Stationary Structure

1. The switchgear structure shall be of "one-high" construction and constructed of formed sections of specially smooth and leveled steel, welded and bolted together and reinforced where necessary with formed steel members. The sides shall be covered with removable bolt on covers. The resulting structure shall be rigid and self-supporting. Structural steel channel sills with end covers shall be furnished for mounting and aligning the separate elements of the structure. The steel channels shall be installed in the concrete floor.

2. The rear of structure shall be covered with individual, hinged, padlockable steel doors for access to buses, connections, and other equipment mounted within each cell. The ends of the structure shall be closed with removable steel panels held in place with slotted head bolts or concealed screws. The hinged access doors shall be provided with 2-point latches, door stops, structural reinforcing to prevent sagging, and provisions for padlocking.

3. Secondary control devices and associated wiring shall be isolated from all high voltage primary devices by grounded metal barriers. Primary circuits such as circuit breakers, transformers, and buses shall also be isolated from each other and from personnel by grounded metal barriers.

4. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to Contractor supplied floor sills to be set level in concrete per manufacturer's instructions. Provisions shall be made for jacking of shipping groups for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids.

5. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument cells, a centralized main bus compartment, and a rear cabling compartment. Each individual circuit breaker compartment, or cell, shall be segregated from adjacent compartments and sections, including the bus compartment, by means of grounded steel barriers. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Current transformers for circuit protection and instrumentation shall be located within the appropriate breaker cells.

6. The stationary part of the primary disconnecting devices for each vacuum power circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the power circuit breaker studs which engage in only the CONNECTED position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit shall include the necessary three-phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with insulated copper load extension busses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be silver-plated where outgoing terminals are attached.

7. The primary insulated bushings shall be suitable for mounting two (2) current transformers on each side (line and load) for a minimum total of four (4) sets of current transformers.

8. The secondary disconnecting devices shall consist of a plug mounted on the removable unit and engaging a socket mounted in the compartment. The secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in the CONNECTED and TEST positions.

9. The removable vacuum power circuit breaker element shall be equipped with disconnecting contacts, wheels, and interlocks for drawout application. It shall have four positions, CONNECTED, TEST, DISCONNECTED and REMOVE all of which permit closing the compartment door. The breaker drawout element shall contain a worm gear levering "in" and "out" mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering "in" and "out" of the cell. The breaker shall include a provision for padlocking. The padlocking shall secure the breaker in the CONNECTED, TEST, or DISCONNECTED position by preventing levering.

10. Hinged doors with removable hinge pins shall be provided for the fronts of the drawout vacuum power circuit breaker compartments.

11. Hinged panels shall be provided for mounting of meters, protective relays, and other devices. Doors and panels shall be equipped with concealed hinges and suitable latches. Doors and panels shall have one-inch (1") deep formed edges with double returns where necessary to assure stiffness.

12. A steel safety shutter shall be furnished to automatically cover the bus stabs in the circuit breaker compartment when the circuit breaker unit is moved to the TEST, DISCONNECTED, or REMOVE position.

13. Provide a rear compartment steel barrier between the cable compartment and main bus to protect against inadvertent contact with the main bus. Provide full height and depth metal barriers between adjacent vertical structures in the cable compartment. Provide a full height and depth glass polyester barrier with appropriate slots for the main bus between adjacent vertical structures in the bus compartment.

14. Equip each cable compartment to accept the termination of 35kV class conductors complete with completed 35kV shielded power cable termination kits. Each cable compartment shall be suitable for the specified cable, of quantity and size as indicated on the Drawings.

15. All "space" compartments specified herein or indicated on the Drawings shall be furnished as "prepared spaces" or "futures" complete with buses, supports, insulators, primary and secondary disconnects, lugs for future outgoing cables, and rails ready to receive a future vacuum power circuit breaker of appropriate size. Insulating barriers shall be installed in the cubicles to cover all live terminals to prevent accidental contact.

16. The withdrawal type units and the stationary sections for these units shall be assembled in jigs which accurately locate the contacts, holding devices, and interlocks. One removable unit of each type and rating shall be tried in each stationary compartment of same type and rating. Each stationary compartment shall be checked with its own removable unit to insure interchangeability.

17. Equip each incoming line main circuit breaker cell with distribution class metal oxide surge arresters. The surge arresters shall be suitable for the application with a maximum continuous operating voltage (MCOV) rating based on higher switchgear ambient (55°F) conditions. The arresters shall be designed, tested, selected, and installed in accordance with ANSI C62 - Guides and Standards for Surge Protection.

    Each feeder circuit breaker cell shall also be furnished with distribution class surge arresters as indicated on the Drawings.

18. **Provide a minimum of two (2) 4" infrared inspection ports in the rear door of each section. IR ports shall be located to allow IR observation of all cable terminations within the rear cable compartment. IR ports shall meet requirements of IEEE C37.20.2, and shall be as manufactured by Hawk IR International, Inc., or equal.**

D. Bus

1. Buses and main connections shall consist of flat copper bars or tubular bus.

2. The main bus shall be fully insulated for its entire length with a flame-retardant and track-resistant epoxy coating installed by the fluidized bed process. Provide the 3 phase bus of each unit with insulation to completely encase each bar, except provide removable, insulating boots at bus joints.

3. The bus shall be braced to withstand fault currents equal to the close and latch (momentary) rating of circuit breakers.

4. Access to the main bus compartment shall be from the rear of the structure after removing the steel barrier.

5. Bus supports between units shall be cycloaliphatic epoxy. All bus joints shall silver plated and be insulated with easily installed boots. The bolted bus joints shall use constant pressure washers for positive contact.

6. An uninsulated ground bus of adequate capacity shall be furnished and installed throughout the switchgear structure. Each stationary unit shall be effectively connected to this ground bus. A substantial ground contact shall be provided between each breaker and removable element and the ground bus, which shall automatically be made before the primary contacts touch. Contact engagement to the ground bus shall be maintained in the CONNECTED and TEST positions.

7. The uninsulated ground bus shall be tin-plated copper bar. Ground each housing directly to this bus. Ground relay panels with a No. 6 AWG insulated copper wire to the ground bus.

8. All main and ground buses shall be extended through the entire length of the switchgear assembly. All busses shall have provisions for future extension.

E. Removable Element

1. The removable element of each circuit breaker unit shall consist of a 3-pole vacuum circuit breaker with trip-free stored-energy mechanism, positive mechanical interlock, primary and secondary disconnecting devices, auxiliary switches, position indicator, and control wiring. The removable element shall have four positions: CONNECTED, TEST, DISCONNECTED, and REMOVE, all of which permit closing of the compartment door.

2. Provide for padlocking of the removable element in the TEST and DISCONNECTED position. Lock shall not interfere with operation of the breaker and its mechanism.

3. Provide an interlock on each circuit breaker unit to prevent the circuit breaker from being removed while breaker is closed and to prevent breaker from being placed in the CONNECTED position unless the breaker is open. If the circuit breaker is closed, the interlock shall trip the breaker before it can be placed in the CONNECTED position.

4. Interlocks shall be provided to prevent closing of the circuit breaker between the CONNECTED and TEST positions, to trip breakers upon insertion or removal from the housing, and to discharge the stored energy mechanisms upon insertion or removal of the circuit breaker from the housing. The circuit breaker shall be secured positively in the housing between and including the CONNECTED and TEST positions.

F. Circuit Breakers

1. Each drawout vacuum power circuit breaker shall be capable of being withdrawn on rails or guide channels and shall be enclosed in a separate metal compartment. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

2. Vacuum circuit breakers shall have the following minimum ratings:

a.	Nominal voltage:	23.9 kV
b.	Maximum voltage:	27 kV
c.	BIL rated:	125 kV
d.	Continuous current:	1200 A
e.	Short circuit current at rated maximum kV:	16 kA
f.	Closing and latching capability:	43 kA
g.	Three-second rating	16 kA
h.	Rated interrupting time:	Five cycles

3. Circuit breakers shall be suitable for application in their enclosures for 100 percent of their continuous current rating.

4. Circuit breakers of equal rating shall be completely interchangeable.

5. Equip each circuit breaker with silver-plated secondary disconnecting contacts to automatically engage in the CONNECTED position and manually engage in the TEST position to complete circuits as required.

6. Provide a means for racking the circuit breaker in and out of the cell and between positions. Provide a means for holding the circuit breaker in the cell in all positions. Include a provision for padlocking open to prevent manual or electric closure of the circuit breaker.

7. Provide interlocking to prevent a closed circuit breaker from racking to or from any position. Provide an additional interlock to assure automatic discharging of the closing springs upon insertion or removal of the breaker into or out of the cell.

8. Provide key interlocks as indicated on the Drawings.

9. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit which can be removed easily. The vacuum interrupter pole unit shall be mounted on cycloaliphatic supports. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its cell. The current transfer from the vacuum interrupter moving stem to the breaker main conductor shall be a non-sliding design. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.

10. A TEST position for each vacuum power circuit breaker shall be provided and so interlocked to insure proper sequence and safe operation.

11. Each circuit breaker shall be provided with "a" and "b" auxiliary contacts which will open or close when the breaker is open or closed. Each breaker shall also be provided with an alarm switch or contact to indicate that the breaker has tripped. All of these contacts shall be wired to terminals in each cell for use in indicating breaker status. Each circuit breaker shall be furnished with enough auxiliary contacts for a complete and operable circuit breaker control circuit and to indicate breaker position as required for this Contract.

12. The vacuum power circuit breakers shall be electrically operated by a 48 volt DC close and 48 volt DC trip. The control voltage shall be derived from the DC control voltage system specified herein and indicated on the Drawings.

13. All circuit breakers shall be furnished with Device 86 lock-out relay.

14. All circuit breakers shall be furnished with a trip coil monitor (TCM) function for indicating trip coil failure. TCM shall be provided with a minimum of one (1) alarm contact for remote indication of trip coil failure.

15. All feeder circuit breakers and utility main circuit breaker shall be provided with a maintenance mode selector switch to reduce the let-thru current in the circuit breaker. This shall be accomplished by using an alternative “maintenance mode” curve in the relay and the switch toggles between “normal” and “maintenance”

modes of operation. The switch shall illuminate in a blue color when activating the maintenance mode.

G. Protective Relaying and Power Monitoring

1. The switchgear manufacturer shall furnish and install in the switchgear the quantity, type, and rating of protective relays and power monitors as specified herein and indicated on the Drawings.

2. Protective relays and power monitors shall be provided completely programmed, using the results from the 16055 Power System studies, relay manufacturer recommended settings for the given application, and industry best practices. This requires **each function listed herein** to be appropriately set as an alarm or tripping function in each relay and the appropriate logic to be programmed into the alarm or tripping characteristics of each relay. The derivation of settings (over and above the power system protective settings), programming, and implementation of settings in the relays is the sole responsibility of Caterpillar or their selected integrator. **Equipment will not be approved for energization by the Owner/Engineer until all testing and settings, including these relay settings, have been approved.**

3. Each circuit breaker cell (except for the generator circuit breaker) shall be furnished with a door mounted, multifunction, microprocessor based feeder protective relay. The device shall be true RMS sensing of each phase and ground. The unit shall be operational from a 48VDC control power source. The device shall provide the following minimum protective and metering functions:

Device ID	Function
25	Synchrocheck
27	Undervoltage
32	Reverse Power
50/46	Negative Sequence IOC
51/46	Negative Sequence TOC
47	Negative Sequence Voltage
50P	Phase IOC
50N	Neutral IOC
50G	Ground IOC
51P	Phase TOC
51N	Neutral TOC
51G	Ground TOC
59	Overvoltage
59N	Neutral Overvoltage
67/46	Directional Overcurrent (Utility Main)
59N	Neutral Overvoltage
81U	Underfrequency
81O	Overfrequency

The relay shall accurately meter, calculate, and display the following:

- current
- voltage
- power (kW, kVAR, kVA)
- energy use (MWh, MVARh)
- power factor
- frequency
- demand current (real-time)
- demand power (kW, kVAR, kVA) (real-time)
- peak demand current
- peak demand power (kW, kVAR, kVA)

The device shall be furnished with a minimum of one (1) RS-232 port and one (1) RS-485 port. Each of these ports shall support ModBus protocol.

The device shall be a Schweitzer Engineering Laboratories SEL-751#12 with voltage input card and color touchscreen display or equal.

4. The generator circuit breaker cell shall be furnished with a door mounted, multifunction, microprocessor based feeder protective relay. The device shall be true RMS sensing of each phase and ground. The unit shall be operational from a 48VDC control power source. The device shall provide the following minimum protective and metering functions:

Device ID	Function
12	Overspeed
24	Overexcitation, Volts/Hz
27	Undervoltage
38	Bearing Overtemperature
39	Bearing Vibration (Analog Inputs)
50/51 GN	Instantaneous or Definite Time Overcurrent
59GN/27TN	100% Stator Ground
50/27	Inadvertent Generator Energization
50BF	Breaker Failure Detection
51V	Voltage Restrained Phase Overcurrent
32	Reverse Power for Anti-Motoring
40Q	Loss of Field
46	Negative Sequence Overcurrent (I^2t)
47	Voltage Phase Reversal
49	Stator Thermal (RTD)
59	Overvoltage
60FL	VT Fuse Failure Detection
81 O/U	Over/Under frequency
87G	Phase Differential

The relay shall accurately meter, calculate, and display the following:

- current
- voltage
- power (kW, kVAR, kVA)
- energy use (MWh, MVARh)
- power factor
- frequency
- demand current (real-time)
- demand power (kW, kVAR, kVA) (real-time)
- peak demand current
- peak demand power (kW, kVAR, kVA)

The device shall be furnished with a minimum of one (1) RS-232 port and one (1) RS-485 port. Each of these ports shall support ModBus protocol.

The device shall be a Schweitzer Engineering Laboratories SEL-700G1+ with voltage input card and color touchscreen display or equal.

5. The microprocessor based relays shall be programmed and wired to (1) trip and lock out switchgear -or- (2) trip and not lock out switchgear, based upon the functions and settings outlined herein and as selected by the manufacturer's provided relay setting provider. Relay settings provider shall document each trip and trip/lockout function in each relay and provide information to Owner/Engineer for review.

6. The switchgear assembly shall be furnished and installed with a Cutler-Hammer Power Xpert 6000 power quality meter with graphic display module or SEL equivalent as indicated on the Drawings. The meter shall be supplied from the 48VDC control power source. A communication expansion card to support Ethernet communication to the plant control system and a 1GB memory card shall be provided with each meter.

7. The switchgear manufacturer shall interconnect all of the multifunction relays and power quality meters via their respective the RS-485 or Ethernet communication ports. These devices shall communicate directly with PLC-13.

H. Direct Current Battery Systems for Switchgear Control

1. Furnish and install battery systems as indicated on the Drawings and specified herein, to operate breaker mechanisms, power monitors, and protective relays.

2. The battery system shall be capable of operating 50% of the circuit breakers simultaneously. One minute discharge rate down to final 1.14 volt/cell shall be equal to trip current drawn by 50% of breakers tripping simultaneously.

3. Batteries shall be sealed pocket plate nickel-cadmium type, cabled to produce a 48 VDC output.

a. Each switchgear cubicle shall have a fused direct current circuit. Provide batteries with a rack assembly to house the batteries and charger.

b. Furnish a current limiting battery charger to automatically recharge the batteries. The charger to float at 1.45 volts per cell and equalize at 1.55 volts per cell. Include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, direct current ammeter, and fused alternating current output. Amperage output to be not less than 20 amperes. Charger shall be as manufactured by Charles Industries, LeMarche, or equal.

4. Minimum battery system ratings shall be as required by the switchgear manufacturer plus 25% spare capacity. Submit battery system sizing calculations in the shop drawings.

5. The battery system including batteries, battery rack, battery charger, DC panelboard and other required equipment shall be provided by the switchgear supplier for installation in main electrical power center enclosure. Reference Section 16470 – Panelboards for information regarding the DC panelboard.

I. Operation and Interlocks for the 27kV Switchgear

1. Normally, the 27kV bus section will operate with the electrical utility main circuit breaker and bus tie circuit breaker in the CLOSED position and the generator tie circuit breaker in the OPEN position.

2. The main feeder breaker shall be electrically interlocked (and mechanically kirk-key interlocked) with the backup feeder breaker to function as follows:

a. Prevent closing the backup feeder breaker when the main feeder breaker is CLOSED.

b. Prevent closing the main feeder breaker when the backup feeder breaker is CLOSED.

J. Current Transformers

1. Ring type current transformers shall be furnished as specified herein and indicated on the Drawings. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers.

2. Current ratio shall be as indicated on the Drawings. Multi-tap primary transformers shall be provided as indicated on the Drawings.

3. Current transformers shall be suitable for metering and relaying applications. Transformers shall be rated in accordance with ANSI Standard C57.13, with accuracy of the current transformers suitable for BO.5 metering accuracy at rated burden. The current transformers shall be sized for the necessary burden for the required devices, minimum.

4. Identify the current transformers for polarity with standard marking or symbols. The transformers shall be capable of carrying rated primary current continuously without damage.

5. Secondary wiring from current transformers shall be routed in suitable wiring trough or conduit to proper short-circuiting type terminal blocks for connection to protective relays, instruments, and other devices.

6. Locate the current transformers on the bus side and line side of the circuit breaker units to be front accessible to permit adding or changing transformers without removing high voltage insulation connections.

K. Voltage Transformers

1. Voltage transformers shall be indoor dry type, single-phase, 60 hertz.

2. Voltage transformers shall have an accuracy classification determined according to ANSI Standards. The voltage transformers shall be suitable for metering accuracy, the burden to be served for the required devices plus 20 percent, and shall meet the following minimum requirements:

a.	BIL:	125kV
b.	Primary Voltage:	23.9 kV
c.	Secondary Voltage:	120 volts.
d.	Metering Accuracy Class:	0.3 at rated burden

3. Identify polarity with standard markings or symbols. Connect secondaries to voltage buses as required. Protect voltage transformers with primary and secondary fuses. Protect the primary side with current-limiting fuses.

4. Voltage transformers shall be mounted in drawout drawers contained in an enclosed auxiliary compartment. Rails shall be provided (see Accessories) to permit easy inspection, testing, and fuse replacement. Automatic shutters shall be furnished to isolate primary bus stabs when the drawers are withdrawn from the cell.

L. Control Power Transformers

1. Provide control power transformers (CPT) as specified herein, indicated on the Drawings, and as required. Furnish control power transformers that have adequate capacity for the load to be served plus 25%.

2. Protect control power transformers. Protect primary side with current limiting fuses. Protect the secondary side with a molded case circuit breaker.

3. Control power transformers for space heaters, lighting, receptacles and other ancillary loads shall be separate from those used for control circuits.

4. Control power transformers shall be fixed mounted with primary fuses in drawout drawers. Rails shall be provided (see Accessories) to permit easy inspection, testing, and fuse replacement. Shutters shall isolate primary bus stabs when drawers are withdrawn.

5. A mechanical interlock shall be provided to require the CPT secondary circuit breaker to be open before the CPT primary fuse drawer can be withdrawn.

M. Control Wiring and Testing

1. Wire and factory test switchgear to satisfy the requirements of the operation described or necessary.

2. Switchgear secondary wiring shall be NEC Type SIS, single-conductor, stranded copper, rated 600 volts, 90°C bundled and secured with nylon ties. Provide flexible stranding for swinging doors and panels. Minimum wire size shall be No. 14 AWG for voltage transformer and control circuits. For current transformer circuits, minimum wire size shall be No. 12 AWG. Number 10 AWG or larger shall be used to decrease resistance as required.

3. Route outgoing control wires for outgoing or "cell-to-cell" interconnecting wiring to the master terminal blocks with suitable numbering strips numbered in agreement with the manufacturer's detailed wiring diagrams.

4. Terminate control wiring in molded terminal blocks acceptable to Engineer. Provide a minimum of 10 percent (10%) spare terminal blocks for each circuit breaker and auxiliary compartment. Compression type terminal blocks are not acceptable. Terminal blocks shall be States Company sliding link Type NT or as accepted by Engineer.

5. Number wiring with shrink-type tag devices at both ends consistent with the manufacturer's detailed wiring diagrams. Duplication of wire numbers and terminal block numbers is not acceptable.

6. One control circuit cut-out device shall be furnished in each circuit breaker housing.

N. Instruments, Meters, Protective Relays and Control Devices

1. The switchgear manufacturer shall furnish and install in the switchgear instruments, meters, protective relays, and control devices complete with devices and associated circuitry necessary to perform the required functions specified herein and indicated on the Drawings. Manufacturers of relays and controls are listed to describe system operating requirements. Other manufacturers will be considered where equivalent relay operating characteristics can be provided as accepted by the Engineer. Any material not specifically listed or shown but necessary to perform required functions shall be furnished.

2. Mount instruments and relays on the hinged doors secured to the stationary structure. Devices shall have enclosing cases, dull black finish, and mounted semi-flush. Provide nameplates per Section 16195, Electrical - Identification.

3. Panel mounted protective relays shall be switchgear non-drawout type with (if available) built-in testing facilities.

4. Instrument and control switches shall be rotary operated type with means for maintaining contact position. Contacts shall be silver-to-silver, enclosed in easily removable protective covers. Provide indicating lights for circuit breakers with low voltage indicating lamps. Lamps shall be easily removable from front of panel and shall be LED type. Indicating lights shall be NEMA rated, 30 mm with chrome bezel.

5. Furnish wiring, potential bus, necessary fuses, and terminal blocks within each cell. Shield secondary and control wiring within the high voltage cell in a protective metal covering.

6. Requirements for items mounted on hinged doors or panels are as follows:

    a. Semi-flush mounting unless otherwise noted.

    b. Items specified as drawout case type shall be removable-chassis construction providing for removal of the relay from the case without disconnecting the leads or removing the case from the panel. The associated current-transformer secondaries shall automatically short-circuit at the case when the relay is removed from its case. Furnish built-in test facilities and visible self aligning contacts.

    c. Instruments shall be in accordance with ANSI C39.1, 1 percent accuracy class, 4-1/2 inch nominal square, with 250 degrees scale unless otherwise noted.

    d. Terminal blocks, wireways, wiring, device mounting brackets, and other miscellaneous items shall be provided as required.

7. Microprocessor based customer metering shall be provided as specified in the Description of Sections below.

8. A test switch shall be installed in the secondary circuit between each instrument transformer and the device (i.e. protective relay, power meter) the instrument is supplying. The test switch wiring shall be plainly marked to indicate the respective circuits to each pole of the switch. Test switches shall be ABB FIexitest Type FT-1 with clear cover, or equal.

O. Nameplates

1. Provide engraved plastic nameplates to identify switchgear units, door mounted devices, and internal components.

2. Nameplates shall be as specified in Section 16195, Electrical - Identification engraved with the circuit number and circuit name as indicated on the Drawings.

3. Label the switchgear per the requirements of the NEC and ANSI C37.20.2.

4. Provide a master nameplate giving switchgear designation, voltage-ampere rating, short circuit rating, manufacturer's name, general order number and item number.

5. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

P. Switchgear Equipment

1. Furnish and equip the circuit breaker compartments and auxiliary compartments as previously specified and as follows:

   a. Vacuum circuit breaker unit including 1 set of primary disconnecting devices and current transformers, and, where specified or required, potential transformers with fuses.

   b. Vacuum circuit breaker faceplate with a breaker open/close position indicator, closing spring charged/discharged indicator, push-to-trip button, push-to-close button, operation counter, breaker latch, and manual spring charging access.

   c. Door-mounted circuit breaker pistol grip control switch with red (closed) and green (open) indicating lights to indicate breaker contact position.

   d. Top and/or bottom entries for power cable entry as required and as indicated on the Drawings.

   e. Ground bus extending the full length of the switchgear. Provide lugs at each end of the bus for ground cable terminations.

   f. Auxiliary contacts, auxiliary relays, and interposing contactors as required to provide remote interlocking and indicating functions specified herein and indicated on the Drawings. Provide 2 spare normally open and 2 spare normally closed contacts per auxiliary relay, contactor, and similar equipment.

2. Switchgear shall be furnished complete with fused, thermostatically controlled space heaters. One space heater shall be installed in each vertical structure. Utilize tubular type operated at half voltage for long life; 250 volt rated heaters at 120 volt. Provide power supplies to the space heaters shall be as specified herein and indicated on the Drawings. The Contractor shall wire heaters to provide temporary heating during storage.

Q. Description of Sections

1. In addition to the specified basic equipment common to all switchgear sections, equip the various individual sections with instruments, protective relays, and control devices as described below. Arrange the equipped sections side by side to form continuous switchgear lineups as indicated on the Drawings.

2. Furnish transition sections as required and as indicated on the Drawings to make the transition from vacuum circuit breaker switchgear sections to load interrupter

switchgear sections. Furnish and install a transition section where making a bus-to-cable transition. Construction of sections shall be as required to make the required transition and shall comply with the applicable sections of this specification.

3. The detailed descriptions which follow are intended to describe basic features of the equipment required and are not intended to specify all devices and materials necessary. It shall be the manufacturer's responsibility to provide and install, as required, all auxiliary relays, auxiliary transformers, terminal strips and such devices and materials required to provide complete units ready for installation and operation.

   a. The main utility circuit breaker section and respective instrument compartment shall contain the following:

      i. 1,200 ampere frame circuit breaker, electrical close and trip.

      ii. Microprocessor based feeder protection relay as specified herein.

      iii. Circuit breaker control switch with breaker status (open-closed) indicating lights.

      iv. Power quality meter as specified herein and indicated on the Drawings.

      v. Three (3) current transformers: ratio as indicated on the Drawings.

      vii. Zero sequence ground current sensor.

   b. The generator circuit breaker section and respective instrument compartment shall contain the following:

      i. 1,200 ampere frame circuit breaker, electrical close and trip.

      ii. Microprocessor based feeder protection relay as specified herein.

      iii. Circuit breaker control switch with breaker status (open-closed) indicating lights.

      iv. Power quality meter as specified herein and indicated on the Drawings.

      v. Three (3) current transformers: ratio as indicated on the Drawings.

      vii. Zero sequence ground current sensor.

   c. The tie circuit breaker section shall contain the following:

      i. 1,200 ampere frame circuit breaker, electrical close and trip.

      ii. Microprocessor based feeder protection relay as specified herein.

iii. Circuit breaker control switch with breaker status (open-closed) indicating lights.

iv. Power quality meter as specified herein and indicated on the Drawings.

v. Three (3) current transformers: ratio as indicated on the Drawings.

vii. Zero sequence ground current sensor.

c. Each feeder circuit breaker section shall contain the following:

i. 1,200 ampere frame circuit breaker, electrical close and trip.

ii. Microprocessor based feeder protection relay as specified herein.

iii. Circuit breaker control switch with breaker status (open-closed) indicating lights.

iv. Three (3) current transformers: ratio as indicated on the Drawings.

vi. Zero sequence ground current sensor.

R. Warning Signs

1. Provide a minimum of two (2) warning signs on the front of the switchgear lineup and two (2) on the back.

a. Red laminated plastic engraved with white letters approximately 1/2 inch high.

b. Signs shall read "DANGER HIGH VOLTAGE"

S. Source Quality Control

1. Completely assemble, wire, and test the switchgear at the factory. Detailed inspections before and after assembly shall assure correctness of design and workmanship. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.

2. After assembly, provide the switchgear with lifting channels having eyebolts for attachment of crane slings to facilitate lifting and handling each shipping-assembly unit. These lifting channels shall be removable after equipment is placed on permanent foundations.

T. Accessories

1. Switchgear accessories shall be provided by the switchgear manufacturer for test, inspection, maintenance, and operation as follows:

   a. One (1) maintenance tool for manually charging the breaker closing spring and manually opening the shutter

   b. One (1) levering crank for moving the breaker between the TEST and CONNECTED positions

   c. One (1) test jumper for electrically operating the breaker while out of its cell

   d. One (1) breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails (if required)

   e. One (1) set of rail extensions and rail clamps (if required)

   f. One (1) portable lifting device or lift truck for lifting the breaker on or off the rails

   g. One (1) "dockable" transport dolly for moving breaker about outside its compartment

   h. One (1) ramp for rolling breaker directly onto the floor.

   i. One (1) test cabinet for testing electrically operated breakers outside the cell

   j. Red plastic mimic bus on the front of the switchgear assembly

   k. One (1) motorized remote racking device for moving a circuit breaker between the TEST and CONNECTED positions.

   l. Two (2) SEL-C662 – USB to Serial Port Cable, 6 feet – to connect to and program the new SEL relays within the switchgear.

U. Finish

1. The switchgear finish shall consist of gray (ANSI-61), thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray. Prior to shipment, the complete assemblies, indoor as well as outdoor, shall be given 1.5 to 2.0 mil thick exterior finish spray coat of air drying high-gloss gray enamel.

2.03 CLOSED TRANSITION AUTOMATIC TRANSFER CONTROLS

A. Controls shall be provided to allow closed transition power transfer between the standby power generator and the utility. The controls shall include devices to automatically synchronize and parallel the new generator set with the electric utility. Once in parallel, the load controls shall softly load/unload the generators as required to provide zero power transfer at separation, and at retransfer to the utility. The controls shall also have the ability to operate the generator continuously in parallel with the utility source in a base loaded mode or a load following mode.

B. The generator and transfer controls shall consist of the following components and features as a minimum:

1. An automatic, digital, load control and synchronizing system. This system shall consist of microprocessor based synchronizing and load sharing controllers for each generator source and each utility source. The synchronizing and load sharing controllers shall control all aspects of generator set operation including, but not limited to, voltage control, speed control, automatic engine starting and stopping, synchronization, load sharing, VAR sharing, power factor control, and generator circuit breaker control. The synchronizing and load sharing controllers shall be the Woodward MSLC-2 and DSLC-2.

3. A Master Generator Switchgear PLC (PLC-13) and a digital operator interface to allow monitoring and control of the generator system. The PLC shall be a CompactLogix as manufactured by Allen Bradley. The PLC shall have redundant online CPUs so that all generator control functionality is maintained in the event one CPU fails. The PLC shall be furnished with a gateway or third party communications module (ProSoft Technology, or equal) to communicate with other devices using Modbus (or any type of serial) protocols. The PLC configuration and communications protocol shall be compatible with the existing SCADA system.

The Master Generator Switchgear PLC shall be provided with a network switch to connect all components of the generator/switchgear system and provide a connection point to the existing SCADA network. Network switch shall match the Hirschmann make/model of existing switches throughout the plant. Coordinate switch details with Owner/Engineer.

The operator interface shall be a 15 inch (diagonal), color TFT industrial display. This display shall support a minimum resolution of 1024 x 768 pixels. Interface shall be accomplished via a key protected touch screen permanently affixed to the display. The touch screen shall be clear glass, with light transmission of 95% or better, furnished with a surface acoustic wave touch interface. Resistive or capacitive touch interfaces are not acceptable. Navigation and operation shall be intuitive such that help screens are not required. The operator interface shall support complete generator set and system control in both automatic and manual modes. The operator interface shall be furnished with Ethernet communication capabilities to communicate with the Master Generator Switchgear PLC (PLC-13). The touch screen display shall provide indication of the following signals for each generator (minimum):

- Engine Run
- Engine Stopped
- Engine Overspeed
- Low Oil Pressure Alarm
- Low Oil Pressure Shutdown
- Engine Temperature Alarm
- Engine Temperature Shutdown
- Engine Summary Alarm
- Engine Summary Shutdown
- Gen Breaker Protective Relay Alarm
- Engine Control Switch (ECS) in Off position
- Engine Control Switch (ECS) in Manual position
- Engine Control Switch (ECS) in Auto position
- Engine Control Mode Switch (at Engine-Generator Set) in “Auto” Position
- Low/High Battery Voltage
- Engine in Cool Down Mode
- Battery Charger Failure
- Gen Breaker Fail to Close
- Gen Breaker Fail to Open
- Gen Breaker Open
- Gen Breaker Closed
- Gen Breaker Tripped

The touch screen display shall provide the following signals and commands for main system control:

- Generator System Control Switch (SCS) in “Auto” Position
- Master Generator Switchgear PLC Failure
- Station Battery Failure
- Utility Source Available
- Utility Source Failed
- Utility Source Protective Relay Alarm
- Utility Breaker Open
- Utility Breaker Closed
- Utility Breaker Tripped
- Utility Breaker Locked Out (86)
- System General Alarm

Graphic displays shall be created to provide indication of the signals described above. As a minimum, provide a graphic display screen for each of the following:

- Overall system including the utility circuit breakers, incoming utility voltage, power distribution buses, the generator and respective circuit breakers, the generator bus, and tie circuit breakers
- Each generator system including each generator with respective controls and generator circuit breaker.
- Event summary display.
- Alarm summary display.

5. Control power system for the generator control system components, the operator interface, and the PLC. The control power system shall be 24VDC and/or 48VDC utilizing the new switchgear battery system.

6. Hand-Off-Auto selector switch (ECS) for the generator. In the “Hand” position, the generator will start and synchronize to the generator bus. In the “Off” position, the generator will not operate under any condition. In the “Auto” position, the generator start/stop control will be from the generator control system.

7. Generator System Hand-Manual-Auto selector switch (SCS). In the “Auto” position, the generator control system shall automatically transfer from utility to generators. In the “Hand” position, transfer from utility to generators and re-transfer from generators to utility shall be initiated by pushbuttons as specified below. In “Manual” position, the transfer function shall be by the manual circuit breaker controls.

9. Provide a pushbutton to initiate transfer from utility to generators.

10. Provide a pushbutton to initiate retransfer from generators to utility source.

11. The following analog metering for each generator shall be furnished in each Generator Control Panel and for each utility main circuit breaker:

    - Voltmeter, 0-27000V with 4 position phase selector switch for each generator.
    - Ammeter, 0-200A with 4 position phase selector switch for each generator
    - Frequency Meter, 57-63 Hz scale
    - Killowatt Meter 0-3500kW.
    - Power Factor Meter 0.5 lag to 0.5 lead
    - Synchroscope, 360 degree movement, slow/fast (digital display not acceptable) for the utility source and.generator.

12. Door mounted test blocks for all current transformers located at the switchgear.

13. Door mounted test switches as indicated on the Drawings located at the switchgear. Test switch wiring shall be plainly marked to indicate the respective circuits to each pole of the switch. Test switches shall be ABB Flexitest Type FT-1 with clear cover, or equal.

14. Provide system reset pushbutton.

15. Provide emergency stop pushbuttons for the generator.

16. Circuit Breaker open-close control switches with circuit breaker status (open-closed) indicating lights for all circuit breakers.

The generator paralleling and transfer controls, engine generator control panel, and Master Generator Switchgear PLC shall communicate over a Modbus network.

The transfer controls shall be designed so that the system will automatically transfer to the generators in the event of a utility failure and back to utility after the utility source is restored whether the Master Generator Switchgear PLC (PLC-13) is operational or not. The automatic generator synchronizing, paralleling, and closed transition transfer operations shall be initiated using the transfer from/to utility pushbuttons whether the Master Generator Switchgear PLC (PLC-13) is operational or not.

On retransfer, in the event the generator fails to synchronize with the utility and the utility voltage and frequency are within acceptable limits, the transfer controls shall initiate a "fail to synchronize with utility" signal to the plant SCADA system and continue to operate the plant from the generator.

C. The generator system controls shall include the necessary hardware and software to control remote devices and equipment associated with this standby power system. This includes, but is not limited to, motorized dampers, radiators, fuel coolers, battery charger and similar ancillary equipment.

D. Input/Output Schedule:

1. The following new data shall be available from the Master PLC (PLC-13) to the existing plant SCADA system via a Fiber connection. Provide appropriate hardware (communication modules, media converters, etc.) to facilitate this connection at each end of the connection. All generator I/O provided from the generator controller to PLC-13 shall be transmitted via Fiber utilizing the same appropriate hardware at each end of the connection. Coordinate protocols and hardware requirements with the generator manufacturer.

Minimum requirements:

Description	State	Span
Generator Running Status	ON/OFF	N/A
Generator Demand Load	N/A	0-3500 kW
Generator Voltage	N/A	0-5000V
Generator Current	N/A	0-600A
Generator Temperature	N/A	0-300°F
Generator Oil Pressure	N/A	0-100 psi
Generator Breaker Status	OPEN	N/A
Generator Fail	ALARM	N/A
Generator Low Coolant Level	ALARM	N/A
Generator Coolant High Temperature	ALARM	N/A
Generator Winding High Temperature	ALARM	N/A
Generator Fuel Leak	ALARM	N/A
Generator Low Fuel	ALARM	N/A
Generator Fuel Level	N/A	0-100%
Generator Battery Fail	ALARM	N/A
Generator System Not in Auto	ALARM	N/A
Switchgear Battery System Fail	ALARM	N/A
Switchgear Building HVAC-1 Fail	ALARM	N/A
Switchgear Building HVAC-2 Fail	ALARM	N/A
27 kV Utility Breaker Status	OPEN	N/A
27 kV Utility Breaker Status	CLOSED	N/A
27 kV Utility Breaker Status	TRIPPED	N/A
27 kV Utility Breaker Status	FAILED	N/A
27 kV Bus Tie Breaker Status	OPEN	N/A
27 kV Bus Tie Breaker Status	CLOSED	N/A
27 kV Bus Tie Breaker Status	TRIPPED	N/A
27 kV Bus Tie Breaker Status	FAILED	N/A
27 kV Generator Breaker Status	OPEN	N/A
27 kV Generator Breaker Status	CLOSED	N/A
27 kV Generator Breaker Status	TRIPPED	N/A
27 kV Generator Breaker Status	FAILED	N/A
27 kV Main Feeder Breaker Status	OPEN	N/A

Description	State	Span
27 kV Main Feeder Breaker Status	CLOSED	N/A
27 kV Main Feeder Breaker Status	TRIPPED	N/A
27 kV Main Feeder Breaker Status	FAILED	N/A
27 kV Backup Feeder Breaker Status	OPEN	N/A
27 kV Backup Feeder Breaker Status	CLOSED	N/A
27 kV Backup Feeder Breaker Status	TRIPPED	N/A
27 kV Backup Feeder Breaker Status	FAILED	N/A
27kV SWGR Utility Bus Status	ENERGIZED	N/A
27kV SWGR Generator Bus Status	ENERGIZED	N/A
27 kV Kilowatt Utility	N/A	0-10000 kW
27 kV Current Utility	N/A	0-400 A
27 kV Voltage Utility	N/A	0-27000 V
27 kV Power Factor Utility	N/A	0.0-1.0
27 kV Frequency Utility	N/A	58.0-62.0 Hz
27 kV Kilowatt Generator	N/A	0-3500 kW
27 kV Current Generator	N/A	0-200 A
27 kV Voltage Generator	N/A	0-27000 V
27 kV Power Factor Generator	N/A	0.0-1.0
27 kV Frequency Generator	N/A	58.0-62.0 Hz
27 kV Kilowatt Main Feeder	N/A	0-10000 kW
27 kV Current Main Feeder	N/A	0-400 A
27 kV Voltage Main Feeder	N/A	0-27000 V
27 kV Power Factor Main Feeder	N/A	0.0-1.0
27 kV Frequency Main Feeder	N/A	58.0-62.0 Hz
27 kV Kilowatt Backup Feeder	N/A	0-10000 kW
27 kV Current Backup Feeder	N/A	0-400 A
27 kV Voltage Backup Feeder	N/A	0-27000 V
27 kV Power Factor Backup Feeder	N/A	0.0-1.0
27 kV Frequency Backup Feeder	N/A	58.0-62.0 Hz

2. The following data shall be provided to the Master PLC (PLC-13) from networked devices located in the 27kV Switchgear (minimum):

Description	Type	State	Span
27 kV Kilowatt Utility	Serial	N/A	0-10000 kW
27 kV Current Utility	Serial	N/A	0-400 A
27 kV Voltage Utility	Serial	N/A	0-27000 V
27 kV Power Factor Utility	Serial	N/A	0.0-1.0
27 kV Frequency Utility	Serial	N/A	58.0-62.0 Hz
27 kV Kilowatt Generator	Serial	N/A	0-3500 kW
27 kV Current Generator	Serial	N/A	0-200 A
27 kV Voltage Generator	Serial	N/A	0-27000 V
27 kV Power Factor Generator	Serial	N/A	0.0-1.0
27 kV Frequency Generator	Serial	N/A	58.0-62.0 Hz
27 kV Kilowatt Main Feeder	Serial	N/A	0-10000 kW
27 kV Current Main Feeder	Serial	N/A	0-200 A
27 kV Voltage Main Feeder	Serial	N/A	0-27000 V
27 kV Power Factor Main Feeder	Serial	N/A	0.0-1.0
27 kV Frequency Main Feeder	Serial	N/A	58.0-62.0 Hz
27 kV Kilowatt Backup Feeder	Serial	N/A	0-10000 kW
27 kV Current Backup Feeder	Serial	N/A	0-400 A
27 kV Voltage Backup Feeder	Serial	N/A	0-27000 V
27 kV Power Factor Backup Feeder	Serial	N/A	0.0-1.0
27 kV Frequency Backup Feeder	Serial	N/A	58.0-62.0 Hz

3. The following data shall be provided from the Plant SCADA system to the Master PLC (PLC-13) via fiber connection to PLC-7:

Description	Type
Initiate Transfer to Standby Generators	NDI
Initiate Retransfer to Utility Source	NDI
Generator 1 Running	NDO
Generator 1 Alarm/Fail	NDO
Plant on Standby Power	NDO
Plant on Utility Power	NDO
Generator in Parallel with Utility	NDO

2.04 SEQUENCE OF OPERATIONS

A. The normal switchgear mode of operation shall be as follows:

1. Utility present. Generator off.

Normal Mode of Operation - Breaker States				
Utility Main	Gen Breaker	Tie Breaker	Main Feeder	Backup Feeder
CLOSED	OPEN	**CLOSED**	**CLOSED [K]**	OPEN [K]

[K] – Electrically Interlocked and Mechanically Interlocked (kirk-keyed)

B. Auto Start/Stop Sequence – Automatic Transfer Upon Utility Failure

1. Initiate start sequence automatically when the selected utility power sources fails and the generator system control switch (SCS) is in the “Auto” position. Generator start sequence shall be automatically initiated if any of the following conditions are detected by the 47N relay:

a. Voltage on any phase of the utility source in service drops 85 percent below nominal voltage or increases above 115 percent of nominal voltage.

b. Frequency drops below 90 percent, or increases above 110 percent of 60Hz.

c. Voltage phase sequence imbalance (negative sequence) increases to or above 5% percent.

The system shall have an adjustable start sequence time delay function of 0-9999 seconds (initial set at five (5) seconds) to allow for momentary utility voltage disruptions.

2. After the start sequence time delay function has timed out, the generator control system shall open the utility circuit breakers and start the generator.

3. When the generator voltage and frequency are within acceptable limits, close its respective generator circuit breaker and connect to the generator bus.

C. Auto Start/Stop Sequence - Return to Utility Source

1. The generator control system shall transfer to the utility source when the voltage, phase voltage balance, and frequency are within acceptable limits and after an adjustable time delay function of 0-120 minutes (initial set at 15 minutes).

1. The generator control system shall synchronize the generator (generator bus) with the utility source and close the utility circuit breaker to operate the generator in parallel with the utility source.

3. The system shall softly unload the generators and open the generator circuit breaker after 95% (adjustable) of the plant load has been transferred from the generator source to the utility source.

4. After the generator circuit breaker is open, run the generator in an unloaded cool down mode for an adjustable time period.

5. When the cool down period is complete, the generator control system shall stop the generator.

D. Auto Start/Stop Sequence – Manual Transfer to Generator Source (Utility Source Available)

1. The Operator initiates transfer to the generator source at the plant PLC Terminal when the SCS is in the “Auto” mode. The Operator can also initiate the transfer to generator source by placing the SCS in the “Hand” position and pressing the “Initiate Transfer to Generator” pushbutton.

2. The generator control system shall start the generator.

3. The generator control system shall synchronize generator with the bus and close the generator circuit breaker when generator voltage and frequency are within acceptable limits.

4. The system shall softly unload the utility source and open the utility circuit breaker after 95% (adjustable) of the plant load has been transferred to the generator source.

E. Auto Start/Stop Sequence – Manual Return to Utility Source

1. The generator control system return to utility source function shall be manually initiated by the Operator only as described above.

2. The Operator initiates transfer to the utility power source at the plant PLC Terminal when the SCS is in the “Auto” mode. The operator can also initiate the transfer to normal source by placing the SCS in the “Hand” position and pressing the “Initiate Transfer To Utility” pushbutton.

3. Once the Operator initiates transfer to the utility power source, the system shall synchronize the generator (generator bus) with the utility source, close utility circuit breaker, and operate the generator in parallel with the selected utility source.

4. The system shall softly unload the generator and open the generator circuit breaker after 95% (adjustable) of the plant load has been transferred from the generator source to the utility source.

5. After the generator circuit breaker is open, run the generator in an unloaded cool down mode for an adjustable time period.

6. When the cool down period is complete, the generator control system shall stop the generator.

F. Manual Start/Stop Sequence – Manual Transfer to Generator Source (Open Transition)

1. Place the SCS in the “Manual” position. In “Manual” mode, all automatic transfer controls, synchronizing controls, and load sharing controls shall be disabled.

2. Manually open the utility circuit breaker (if closed).

3. Start the generator by placing the engine control switch (ECS) in the “Hand” position.

4. Close the generator circuit breaker after the generators are running to supply the plant load as required.

G. Manual Start/Stop Sequence – Manual Transfer to Utility Source

1. Place the SCS in the “Manual” position. In “Manual” mode, all automatic transfer controls, synchronizing controls, and load sharing controls shall be disabled.

2. Manually open the generator circuit breaker. Operate generators in an unloaded cool down mode and manually stop all operating generators at the end of the cool down period.

3. Manually close the utility circuit breaker to supply the plant load.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The switchgear shall be furnished and installed as shown on the Drawings and in accordance with the manufacturer's recommendations and installation instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment. The equipment shall be suitably protected with space heaters connected until accepted by the Owner.

B. Furnish and install structural mounting channels in accordance with manufacturer's recommendations to provide proper alignment of the units.

C. The equipment shall be installed and checked in accordance with the manufacturer's recommendations. This shall include, but not be limited to:

1. Checking to ensure that the pad location is level to within .125 inches every three (3) feet in any direction.

2. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.

3. Assemble all shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.

4. Secure assemblies to foundation or floor channels.

5. Measure and record High-Pot readings phase-to-phase, phase-to-ground, and neutral-to-ground (four-wire systems only).

6. Inspect and install all circuit breakers in their proper compartments.

D. Install the switchgear to allow complete unit door swing required for unit removal. This is specifically required where a vertical section of switchgear is set next to a wall to the left of a switchgear section.

E. The Contractor shall furnish and install all conduit and wire required to provide main, tie, and feeder breaker positions (open, closed) and breaker "TRIPPED" signals as inputs to the plant control system. The Contractor shall also provide any/all communication conduit and wire between all components associated with the generator, switchgear, switchgear relays, CTs, PTs, PLC-13, and Plant SCADA system to provide a complete and operable system. This includes any conduit/wire not indicated specifically herein or on the Contract Drawings.

3.02 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified, factory-trained, manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined in Division 1 and Section 11000, Equipment - General Provisions. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of four (4) working days during installation of the equipment.

2. One trip of two (2) working days for the setting of the protective devices.

3. One trip of one (1) working day after acceptance of the equipment

4. One trip of one (1) working day during the warranty period.

B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Field Representative on each day he is at the project.

3.03 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

3.04 FIELD ADJUSTMENTS

A. The protective relays shall be set in the field by a qualified representative of the manufacturer or outside testing company, retained by the Contractor, in accordance with the settings designated in a Coordination Study of the system as required elsewhere in these Specifications.

3.05 MANUFACTURER'S CERTIFICATION

A. A qualified, factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

- END OF SECTION -

SECTION 16391

NEUTRAL GROUNDING RESISTORS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish, install, test, and place in satisfactory operating condition neutral grounding resistors as specified herein and indicated on the Drawings.

B. All equipment specified in this Section shall be furnished and installed by the generator enclosure manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

1.02 CODES AND STANDARDS

A. The neutral grounding resistors shall be designed, manufactured, assembled, and tested in accordance with IEEE Standard 32-1972, Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts List

45. Reports of Certified Shop Tests.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submissions will be returned to the Contractor without review for resubmittal.

C. Shop drawings for each neutral grounding resistor assembly shall include but not be limited to:

081115BR

1. Product data sheets. Data sheet information shall include line-to-ground voltage rating, resistor rated ampacity and time duration, temperature rise, and assembly enclosure type.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions.

3. Weights of all major component parts, assembled weight of units and approximate total shipping weight.

4. Plan, front and side view drawings, including overall dimensions of each neutral grounding resistor. Show conduit entry/exit locations on the Drawings.

5. Internal wiring diagrams.

6. External connection diagram showing the wiring to the external devices associated with the neutral grounding resistor.

7. Bill of material for each neutral grounding resistor assembly.

8. Manufacturer's installation instructions including anchorage details.

9. Manufacturer's warranty statement.

10. Cable terminal sizes.

D. The submittal information shall reflect the specific equipment identification name and/or number as indicated on the Drawings.

E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 IDENTIFICATION

A. Each neutral grounding resistor shall be identified with the text NEUTRAL GROUNDING RESISTOR on a nameplate. The nameplate shall be securely affixed in a conspicuous place on each assembly. Nameplates shall be as specified in Section 16195 - Electrical Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. It is the intent of these specifications that the neutral grounding resistors be produced by a single manufacturer who shall be responsible for matching all components and providing equipment which functions together as a system.

C. The neutral grounding resistors shall be as manufactured by I-Gard, Avtron Manufacturing, Inc., or equal.

2.02 NEUTRAL GROUNDING RESISTORS

A. General

1. Resistor units shall be stainless steel stamped grid edge wound elements that are double insulated. Resistor terminals shall be stainless steel. All resistor end frames, hardware, and non-current carrying spacers shall be zinc-plated steel. If more than one resistor frame is required, series connections shall be solid copper bus.

2. The neutral ground resistor shall be provided with a NEMA 3R safety enclosure. The enclosure shall provide personnel safety and shall exclude the possible entry of birds, rodents, or other animals from the resistor. The enclosure shall have a solid top, screened bottom, louvered or screened side covers, and top mounted eye bolts for handling ease. The enclosure shall be ANSI 61 gray.

3. The assembly shall be suitable for mounting within the sound attenuated generator enclosure.

B. Ratings

1. The ratings of the neutral grounding resistor shall be as follows and as indicated on the Drawings.

Initial Current Rating	As indicated on the Drawings
System\Line-to-Ground Voltage	4.16kV/2400V
Time Rating	10 Seconds
Temperature Rise	760°C

C. Accessories

1. Each neutral grounding resistor shall include the following accessories:

a. Current transformers mounted within enclosure, ratio as indicated on the Drawings.

b. Base insulators.

c. Entrance bushings and terminal lugs.

D. Warning Signs

1. Warning signs shall be provided in accordance with the requirements of Section 16195 – Electrical Identification.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The neutral grounding resistors shall be installed in the location shown on the Drawings in accordance with the manufacturer's installation instructions.

B. Check all bolted connections to assure that they are in accordance with the manufacturer's recommended torque requirements.

3.02 TESTING

A. The following tests are required:

1. Certified Shop Tests and Reports

a. Submit certified copies of all test reports.

b. The following standard factory tests shall be performed on the equipment provided under this Section. All tests shall be in accordance with the latest version of IEEE Standard 32-1972.

1) Overpotential tests for the resistor element.
2) Ohmic value.
3) Circuit continuity.
4) Inspection of the inner electrical terminal connections.

c. The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the neutral grounding resistors.

2. Field Tests

a. Field tests shall be performed as part of the generator testing and startup procedures. The manufacturer's representative shall conduct testing. All neutral grounding resistor units and related components shall be acceptance tested in accordance with the NETA Acceptance Testing Specifications latest edition.

3.03 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

- END OF SECTION –

SECTION 16426

LOW VOLTAGE SWITCHBOARDS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation, the low voltage switchboards as specified herein and indicated on the Drawings.

B. The line-up shall contain generator and utility main breakers, feeder breakers, metering equipment, control devices, and all accessories as specified herein, indicated on the Drawings, and as required to result in a complete and operable power distribution equipment assembly.

C. The Contractor shall obtain the switchboard from one manufacturer who shall also manufacture the structure and major equipment components, which includes, but is not limited to, circuit breakers, instrument transformers, meters, relays, and controls. Sub-contracting of wiring is not acceptable.

D. The switchboard shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

E. Circuit breaker control and relaying/metering circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings.

1.02 CODES AND STANDARDS

A. All equipment shall be listed by and shall bear the label of Underwriter's Laboratories, Incorporated (U.L.).

B. The equipment shall comply with the following codes and standards:

1. National Electrical Code (NEC)

2. Institute of Electrical and Electronic Engineers (IEEE)

3. American National Standards Institute (ANSI):

   a. C12.1 - Code for Electricity Metering

   b. C57.13 - Instrument Transformers.

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4. National Electrical Manufacturer's Association (NEMA):

   a. AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

   b. PB 2 - Deadfront Distribution Switchboards.

5. Underwriters Laboratories, Inc. (U.L.):

   a. U.L. 98 - Enclosed and Dead Front Switches.

   b. U.L. 489 - Molded Case Circuit Breakers.

   c. U.L. 891 - Dead-Front Switchboards.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

   1. Shop Drawings

   2. Operation and Maintenance Manuals

   3. Spare Parts List

   4. Reports of Certified Shop and Field Tests

   5. Manufacturer's Representatives Installation Certification

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submissions will be returned to the Contractor without review for resubmittal.

C. Shop drawings for <u>each</u> switchboard <u>assembly</u> shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

2. Product data sheets identifying all electrical ratings.

3. Complete assembly, layout, anchoring, and installation drawings with clearly marked dimensions.

4. Approximate total shipping weight of each equipment assembly.

5. Example equipment nameplate data sheet.

6. Plan, front and side view drawings, including overall dimensions of each switchboard assembly. Identify shipping splits and show conduit stub-up area locations on the Drawings.

7. Internal wiring diagram of each low voltage switchboard assembly. Each wiring diagram shall include wire identification and terminal numbers.

8. Internal interconnection wiring diagrams including wiring identification and terminal numbers.

9. Complete single line diagram for each switchboard line-up. The drawing shall indicate devices comprising the switchboard assembly including, but not limited to, circuit breakers, control power and instrument transformers, meters, relays, and control devices. Clearly indicate electrical ratings of all devices.

10. Bill of material list for each switchboard assembly.

11. Nameplate schedule.

12. Manufacturer's installation instructions.

13. Manufacturer's warranty statement.

14. Key interlock scheme drawing and sequence of operations.

The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books and/or leaflets.

2. Recommended spare parts list.

3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process and field installation.

1.06 SPARE PARTS

A. The switchboard shall be furnished with a spare circuit breakers where indicated on the Drawings.

1.07 IDENTIFICATION

A. Each switchboard assembly shall be identified with the identification name and/or number indicated on the Drawings (e.g., SWBD-3). A nameplate shall be securely affixed in a conspicuous place on each switchboard assembly. Nameplates shall be as specified in Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. It is the intent of these specifications that the switchboard be produced by a single manufacturer who shall be responsible for matching all components and providing equipment which functions together as a system.

C. The equipment shall be Pow-R-Line C as manufactured by Eaton, Square D Company equivalent, ABB/GE equivalent, or Siemens Energy & Automation, Inc. equivalent.

2.02 CIRCUIT BREAKER SWITCHBOARD

A. General

1. Furnish and install dead-front type, completely metal enclosed, self-supporting electrical equipment including main circuit breaker(s) and molded case branch circuit breaker assemblies of the number, rating and type noted on the Drawings. The equipment shall meet Underwriters' Laboratories requirements and shall be a furnished with a U.L. service entrance label where indicated on the Drawings.

2. The main breaker section and distribution section shall be NEMA Type 1 (gasketed) industrial use enclosures. The main circuit breaker section shall be totally accessible from the front and the sides. The distribution switchboard shall be totally accessible from the front and the sides. Equipment assemblies requiring rear access are not acceptable. The framework shall be of U.L. gauge steel. Ventilation shall be provided as required.

3. All wire troughs shall have hinged doors.

4. The equipment assemblies shall be suitable for operation at the available fault current, 65 kA (minimum). The equipment assemblies shall be labeled to indicate the maximum available fault current rating, taking into account the structure, bussing, main circuit breaker and switchboard branch circuit devices. The short circuit current rating shall not be less than that specified herein or indicated on the Drawings. The distribution switchboard branch circuit devices short circuit current rating shall be fully rated.

5. All bus shall be tin-plated copper. The bussing shall be of sufficient cross sectional area to meet U.L. standard 891 for temperature rise. The fully rated main bus shall have a maximum ampacity as indicated on the Drawings and extend the full length of the equipment. The main bus shall be 100 percent rated. The ground bus shall be sized per U.L. standard 891, installed in the entire length of the equipment assemblies. The distribution switchboard bus shall be rated as required by the rating of the mounted branch devices, including spares or spaces. Full height vertical bus shall be provided to accommodate future circuit breakers. Less than full height vertical bus which will only accommodate the circuit breakers included for this project is unacceptable.

6. Provide engraved plastic nameplates to identify the main circuit breaker and each branch circuit breaker. The circuit number and circuit name shall appear on the nameplate in accordance with the single line diagram(s) indicated on the Drawings. Nameplates shall be as specified in Section 16195, Electrical - Identification.

B. Main and Tie Circuit Breaker Sections

1. The main and tie circuit breakers shall be a fixed type, manually or electrically operated (as indicated on the Drawings), on-off breaker, 100 percent rated with full-function trip system, sensors, and rating plug. The trip unit shall be Optim 1050 as manufactured by Eaton, or equal. Circuit breakers shall have adjustable trip settings which shall match the conductor current ratings.

2. The main circuit breakers shall be capable of being shunt tripped where indicated on the Drawings. The main and tie circuit breakers shall have a short circuit rating as indicated on the Drawings. Trip units shall be provided with full Long Time, Short Time, Instantaneous, and Ground Fault functions.

3. Main circuit breaker trip units shall be provided with an arc-flash reduction mode feature that allows a special set of trip settings to be programmed into the unit for use during maintenance activities.

4. Provide control power and current transformers as required. Provide a minimum of two (2) auxiliary contacts for remote indication of breaker position. Provide other accessories as specified herein or indicated on the Drawings.

D. Distribution Switchboard

1. The distribution switchboard shall include group-mounted branch circuit breakers which are to be totally front accessible and front connectable. The circuit breaker connections to the distribution panel bussing shall be of bolt-on design such that the connections grip the bus bars firmly under high-fault conditions.

2. The switchboard manufacturer shall provide all the proper lugs for all cable connections as required to avoid field modifications.

3. Branch circuit breakers shall be molded case type with ratings as indicated on the Drawings. Branch circuit breakers shall be rated for 65,000 A RMS symmetrical at 480V.

4. Branch circuit breakers with a frame size of 250A and above shall be provided with an adjustable magnetic setting with range of 5 to 10 times the trip rating of the circuit breaker.

E. Metering

1. Each switchboard assembly shall be furnished and installed with an Eaton Power Xpert 6000 Series power quality meter and graphic display module or equal. Power monitors shall be provided for the utility main and the generator main breaker. A communication expansion card to support Modbus TCP communication to the plant control system and a 4GB memory card shall be provided with each meter. The following parameters shall be communicated as a minimum:

- Current (all phases)
- Voltage (all phases)
- KW, KVAR, KVA
- Power Factor

2.03 SURGE PROTECTIVE DEVICES

A. The switchboard shall be furnished with integrated Type II surge protective devices (SPD). SPDs shall be provided in the location and quantity as shown on the Drawings.

B. The SPD shall be rated, designed, tested, listed, and labeled in accordance with UL-1449, latest edition.

C. The SPD shall be factory installed by the switchboard manufacturer using a direct bus connection. There shall be no cable connection between the bus bar and the SPD device.

D. The SPD shall have a fault current rating equal to or greater than that of the fault current rating of the switchboard. The SPD shall employ metal-oxide varistor (MOV) technology. If integral fusing is used, the fuses shall allow the maximum rated surge current to pass without fuse operation.

E. The SPD shall have a maximum continuous operating voltage (MCOV) of at least 115% of the nominal voltage of the switchboard. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

SYSTEM VOLTAGE	L-N	L-G	L-L	N-G
208Y/120	700V	700V	1200V	700V
480Y/277	1200V	1200V	1800V	1200V
480 DELTA	N/A	1200V	2000V	N/A
240 DELTA	N/A	1200V	1200V	N/A
120/240	700V	700V	1200V	700V

F. The Nominal Discharge Current (I_n) of the SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.

The surge current rating for each SPD shall be as indicated on the Drawings. Surge current ratings are indicated on single line diagrams. Surge current rating indicated is on a per phase basis.

G. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

SYSTEM CONFIGURATION	MODES OF PROTECTION	NUMBER OF MODES
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedance Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

H. The SPD shall be furnished with an audible alarm and silence pushbutton, integral SPD status LEDs (one per phase), and a Form C dry contact for remote indication of alarm. A surge counter shall also be provided.

I. The SPD equipment shall be SPD Series by Eaton, SurgeLogic by the Square D Company, Siemens Energy and Automation Inc. equivalent, or equal

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The switchboard shall be furnished and installed as shown on the Drawings and in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment. The equipment shall be suitably protected until accepted by the Owner.

B. The equipment shall be installed and checked in accordance with the manufacturer's recommendations. This shall include but not limited to:

1. Checking to ensure that the pad location is level to within .125 inches.

2. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.

3. Assemble all shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.

4. Secure assemblies to foundation or floor channels.

5. Inspect and install all circuit breakers in their proper places.

3.02 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions, and Division 1. The following tests are required:

1. Witness Shop Tests

a. Not required.

2. Certified Shop Tests and Reports

a. Submit description of proposed testing methods, procedures, and apparatus. Submit notarized and certified copies of all test reports.

b. As a minimum, the entire switchboard assembly shall go through a quality inspection before shipment. This inspection shall include, but is not limited to, the following:

i. Physical inspection of the structure and the electrical conductors including bussing, general wiring, and units.

ii. General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.

iii. AC dielectric tests of the power circuits and control circuits.

iv. Markings/labels, including instructional type, Underwriters Laboratory (U.L.), and inspector's stamps.

The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the switchboard.

3. Field Tests

a. Field tests shall be performed in accordance with requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition

3.04 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified, factory-trained manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

B. The manufacturer’s technical representative shall perform startup and functional testing of the switchboard and controls as specified herein.

C. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of two (2) working days during the installation of the switchboard.

2. One (1) trip of two (2) working days for the testing and startup of the switchboard.

3. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify any issues to be corrected under warranty.

D. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.05 FIELD ADJUSTMENTS

A. The circuit breaker trip units shall be set in the field by a qualified representative of the manufacturer, or an outside testing company retained by the Contractor, in accordance with the settings designated in the coordination study. See Section 16000 – Basic Electrical Requirements.

- END OF SECTION -

SECTION 16440

DISCONNECT SWITCHES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install separately mounted, individual disconnect switches as specified herein and indicated on the Drawings.

B. Disconnect switches for process instruments are not included in the scope of this Section and shall be as specified in Section 16141 – Wiring Devices.

1.02 CODES AND STANDARDS

A. Disconnect switches shall be designed, manufactured, and/or listed to the following standards as applicable:

1. UL 98 – Enclosed and Dead-Front Switches

2. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

3. NEMA 250 – Enclosures for Electrical Equipment

4. NEMA KS 1 – Heavy Duty Enclosed and Dead-Front Switches

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

3. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

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C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of disconnect switch.

3. Assembled weight of each unit.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 SPARE PARTS

A. The equipment shall be furnished with all spare parts as recommended by the equipment manufacturer.

B. One (1) complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the Owner at the time of final inspection.

C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.06 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Switches shall be manufactured by Eaton, Square D Company, ABB/GE, or Siemens Energy & Automation, Inc.

2.02 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy-duty type and/or as specified in these Specifications. Switches shall be furnished and installed as shown on the Drawings and as required by the NEC. Handles shall be lockable.

B. Disconnect switches for non-hazardous areas shall be UL 98 Listed. Disconnect switches for hazardous areas shall be UL 1203 Listed.

C. Switches shall meet NEMA Standard KS 1 type HD requirements, be, single-throw, be externally operated, and be fused or non-fused as indicated on the Drawings. Switches shall have the number of the poles, voltage, and ampere ratings as shown on the Drawings.

D. In non-hazardous locations, disconnect switches shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

E. In hazardous locations, disconnect switches shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

AREA CLASSIFICATION	ENCLOSURE TYPE AND MATERIAL
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 7, Die Cast Aluminum
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 9, Die Cast Aluminum

F. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.

G. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.

H. Disconnect switches shall be furnished with a factory installed internal barrier kit that helps prevent accidental contact with live parts and provides “finger-safe” protection when the door of the enclosed switch is open.

I. Disconnect switches shall be furnished with a manufacturer-supplied ground lug kit for termination of equipment grounding conductors. Where a grounded (neutral) conductor is shown on the Drawings in the conduits connected to the disconnect switch, a manufacturer-supplied neutral bar shall be furnished for termination of the grounded conductors. Third party ground lug and neutral lug kits not supplied by the disconnect switch manufacturer are not acceptable.

J. Fused disconnect switches shall be furnished for motor operated valve and gate actuators where shown on the Drawings. The Contractor shall coordinate the supply of these fused switches with the specific requirements of the actuator. Fuses with fast fault clearing times may be required for modulating valve actuators.

K. Disconnect switches for all motors connected to variable frequency drives (VFDs) shall be furnished with a factory installed electrical interlock kit that includes one (1) early-break auxiliary contact rated for 5A (minimum) at 120 VAC to be used to open the control circuit before the main switch blades break.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All disconnect switches shall be mounted five (5) feet above the floor or finished grade, at the equipment height where appropriate, or where shown otherwise.

B. Disconnect switches shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

- END OF SECTION -

SECTION 16461

DRY TYPE DISTRIBUTION TRANSFORMERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, and test transformers for power and lighting distribution systems as specified herein, as indicated on the Drawings, and as required to complete the electrical installations.

B. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

C. Reference Section 16000, Basic Electrical Requirements.

1.02 CODES AND STANDARDS

A. Transformers shall conform to all applicable Federal, UL, and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.

B. Transformers shall comply with the following standards:

1. UL 1561 – Dry Type General Purpose and Power Transformers

2. U.S. Department of Energy 2016 Efficiency

3. National Electrical Code

4. NEMA ST-20 – Dry Type Transformers for General Applications

5. ANSI C57 – Standard General Requirements for Dry Type Distribution and Power Transformers

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Division 1, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Operation and Maintenance Manuals.

3. Spare Parts List.

4. Reports of Certified Shop Field Tests.

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B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein, and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Drawings showing clearly marked dimensions and weight for each transformer.

3. Sample equipment nameplate diagram.

D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g. TX-LP-3).

E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 IDENTIFICATION

A. Each transformer shall be identified with the equipment item number indicated on the Contract Drawings and the accepted Shop Drawings. A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Dry type distribution transformers shall be Energy Star compliant and manufactured by the Square D Company, Eaton, ABB/GE, or Siemens Energy and Automation, Inc.

2.02 DRY TYPE TRANSFORMERS

A. Furnish and install single-phase and three-phase general purpose, dry-type transformers, as specified herein and indicated on the Drawings. The transformers shall be 60 Hz, self-cooled, quiet-design insulated of the two winding type.

B. The transformers shall be UL 1561 Listed.

C. The primary windings shall be rated 480 VAC for use on 3-phase systems and connected delta unless indicated otherwise on the Drawings. KVA ratings shall be as shown on the Drawings. Furnish transformers with two 2-1/2% primary taps above, and four 2-1/2% primary taps below rated voltage for transformers 15 KVA and above, and two 2-1/2% primary taps above, and two 2-1/2% primary taps below rated voltage for transformers less than 15 kVA. All taps shall be full capacity rated.

D. The ratings of the secondary windings shall be as indicated on the Drawings.

E. Transformers shall be designed for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in IEEE 65 and ANSI C57.96. This performance shall be obtainable without exceeding 150 degrees Celsius average temperature rise by resistance or 180 degrees Celsius hot spot temperature rise in a 40 degrees Celsius maximum ambient and 30 degrees Celsius average ambient. The maximum coil hot spot temperature shall not exceed 220 degrees Celsius. All insulating materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D 635. All insulating materials shall be in accordance with NEMA ST 20 Standard for a 220 degrees Celsius UL component recognized insulation system.

F. Transformer coils shall be of the continuous wound copper construction and shall be impregnated with non-hygroscopic, thermosetting varnish.

G. All cores are to be constructed of high grade, non-aging, grain-oriented silicon steel with high magnetic permeability and low hysteresis and eddy current loses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be tightly clamped and compressed with structural steel angles. The completed core and coil shall then be bolted to the base by means of vibration-absorbing mounts to minimize sound transmission. There shall be no metal-to-metal contact between the core and coil assembly and the enclosure.

H. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees Celsius. Transformers shall be furnished with lugs of the size and quantity required and suitable for termination of the field wiring.

I. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.

J. Transformers shall have core and coil assemblies mounted on rubber isolation pads to minimize the sound levels. Transformers shall not exceed the sound levels listed in NEMA ST-20.

K. Transformers shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 3R, Painted Steel
Indoor Dry Process Area	NEMA 2, Painted Steel
Indoor Dry Non-process Area	NEMA 2, Painted Steel
All Outdoor Areas	NEMA 3R, Painted Steel

L. The enclosure shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with a baked weather-resistant enamel using the manufacturer's standard painting process. Color shall be ANSI 61.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The transformers shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer.

B. Conduit routed to and from the transformer shall be arranged for easy removal of the transformer access covers.

C. Where transformers 50 kVA and smaller are shown to be wall mounted, a transformer manufacturer supplied wall mounting kit shall be used. The lowest point of the wall mounting bracket shall be no lower than 7'-0" above the finished floor. Field fabricated mounting hardware is not acceptable unless reviewed and approved in writing by the Engineer.

D. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Certified Shop Tests

a. The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards. Temperature rises may be certified from basic design.

b. As a minimum, the following tests shall be made on all transformers:

i. Ratio tests on the rated voltage connection and on all tap connections.
ii. Polarity and phase-relation tests on the rated voltage connection.
iii. Applied potential tests.
iv. Induced potential tests.
v. No-load and excitation current at rated voltage on the rated voltage connection.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

b. Insulation between windings shall be tested by 1000 VDC Megaohmeter for one (1) minute. Resistance value shall be no less than 100 Megaohms.

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SECTION 16470

PANELBOARDS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install panelboards of voltage and current ratings as specified herein and indicated on the Drawings. Panelboards shall be furnished with circuit breaker ratings, number of breakers, number of poles and locations conforming to the panelboard schedules on the Drawings.

B. Reference Section 16000, Basic Electrical Requirements; Section 16195, Electrical Identification.

1.02 CODES AND STANDARDS

A. Panelboards shall be designed, manufactured, and/or listed to the following standards as applicable:

1. Underwriters Laboratories

a. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations

b. UL 67 – Standard for Panelboards

c. UL 489 - Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures

d. UL 943 – Ground Fault Circuit Interrupters

2. NEMA PB1 - Panelboards

3. National Electrical Contractors Association (NECA) Standard 407 – Standard for Installing and Maintaining Panelboards

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Spare Parts List.

3. Operation and Maintenance Manuals.

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4. Reports of Field Tests.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each panelboard.

3. Complete panelboard schedules indicating circuit designations as shown on the Drawings for each panelboard.

4. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings (e.g., LP-3, PP-3, etc.).

1.05 OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books and/or leaflets.

2. Recommended spare parts list.

3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process and during field installation.

1.06 SPARE PARTS

A. For each panelboard, all spaces in the panelboards shall be furnished with a spare breaker as indicated in the panelboard schedules shown on the Drawings.

1.07 IDENTIFICATION

A. Each panelboard shall be identified with the identification name/number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each panelboard. Nameplates shall be as specified in Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 CONDUCTORS (MAIN BUS AND BRANCH CONNECTORS)

A. All main bus shall be copper sized in accordance with UL standards to limit the temperature rise on any current carrying part to a maximum of 50 degrees C above a maximum ambient temperature of 40 degrees C.

2.03 LIGHTING PANELBOARDS

A. General

1. Lighting panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal-overload, branch circuit breakers. Panelboards shall be of the configuration and rating as specified herein and indicated on the Drawings. Panelboards shall be UL 67 Listed and shall be constructed to NEMA PB1 standards. Panelboards shall be service entrance rated where indicated on the Drawings.

2. Lighting panelboards shall be equipped with a main breaker or main lugs complete with branch circuit breakers, as indicated on the Drawings. The panelboards shall be suitable for flush or surface mounting.

3. Lighting panelboards shall be fully rated and shall have a minimum short circuit rating of 22,000 amperes symmetrical, unless otherwise indicated on the Drawings.

4. Lighting panelboards shall be Eaton Pow-R-Line Series, the Square D Company equivalent, GE/ABB equivalent, or Siemens Energy and Automation, Inc. equivalent.

B. Enclosures

1. Enclosures shall be UL 50 listed and have a NEMA rating as indicated on the Drawings. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet. Enclosures designated as NEMA 4X shall be constructed of 304 stainless steel. Enclosures with all other NEMA ratings shall be constructed of No. 12 U.S.S. code gauge galvanized steel, painted ANSI #61 light gray. The enclosure shall have wiring gutters on sides and shall be at least 5-3/4 inches deep.

2. The door shall be fastened to the enclosure with concealed hinges and shall be equipped with flush-type catches and locks. The Contractor shall equip cabinet doors exceeding 40 inches in height with vertical bolt three point locking mechanism. All locks shall be keyed alike. The panelboard trim shall have a removable hinge assembly, in addition to the door hinge, that allows work inside the enclosure without the need to remove the trim.

3. The panelboard shall be provided with an information label. The information label shall include the panelboard designation, voltage, phase, wires, and bus rating.

C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1000 amperes per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide full flexibility of circuit arrangement.

2. Solid neutral bus bars are required and neutral bus ampacity shall be the same as the main bus bars unless otherwise noted. Ratings shall be in accordance with applicable standards.

3. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.

4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.

5. All bus shall be tin plated copper and shall extend the entire useable length of the panelboard, including spaces.

D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type and UL 489 Listed. All circuit breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation. Tandem or half-size circuit breakers are not acceptable.

2. Where indicated on the Drawings, or where required by Code, circuit breakers shall be equipped with integrally mounted ground fault interrupters complete with "TEST" push button and shall be of a type which fit standard panelboard spaces for the breaker continuous current rating required. Ground fault circuit interrupter style circuit breakers shall be UL 943 Listed. Circuit breakers used for lighting circuit switching shall be approved for the purpose and shall be marked "SWD". Where required by Article 440 of the NEC, circuit breakers installed for air conditioning units shall be HACR type.

3. Circuit breaker voltage ratings shall meet or exceed the panelboard voltage indicated on the Drawings. Trip elements of circuit breakers shall be 20A unless otherwise indicated on the Drawings. Circuit breakers shall have an interrupting rating at 240 VAC that matches the panelboard short circuit rating.

4. Main circuit breakers shall be individually mounted. Branch mounted circuit breakers are not acceptable unless specifically indicated on the panel schedules. Coordinate top or bottom mounting of main circuit breaker with incoming conduit location.

5. Where indicated on the Drawings, branch circuit breakers shall be provided with a padlockable hasp or handle padlock attachment for padlocking in the off position as required to meet the NEC requirement for disconnecting means and/or OSHA lock-out/tagout standard. Locking hardware shall remain in place even when the packlock is removed. Branch circuit breakers shall be provided with a similar lock-on device where indicated on the Drawings.

E. Directories

1. Approved directories with noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be furnished and installed in each panelboard. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Drawings, except as otherwise authorized by the Engineer.

2.04 POWER DISTRIBUTION PANELBOARDS

A. General

1. Power distribution panelboards shall be of the configuration and rating as specified herein and as indicated on the Drawings. The panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal overload branch circuit breakers. Panelboards shall be UL 67 Listed and shall be constructed to NEMA PB1 standards. Panelboards shall be service entrance rated where indicated on the Drawings.

2. Power panelboards shall be equipped with a main breaker or main lugs complete with branch circuit breakers as indicated on the Drawings. The panelboards shall be suitable for flush or surface mounting.

3. Power distribution panelboards shall be fully rated and shall have a minimum short circuit rating of 65,000 amperes symmetrical unless otherwise indicated on the Drawings.

4. Power distribution panelboards shall be Eaton Pow-R-Line Series, the Square D Company equivalent, the General Electric Company equivalent, or Siemens Energy and Automation, Inc. equivalent.

B. Enclosures

1. Enclosures shall be UL 50 listed and have a NEMA rating as indicated on the Drawings. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet. Enclosures designated as NEMA 4X shall be constructed of 304 stainless steel. Enclosures with all other NEMA ratings shall be constructed of No. 12 U.S.S. code gauge galvanized steel, painted ANSI #61 light gray. The enclosure shall have wiring gutters on sides and shall be at least 5-3/4 inches deep.

2. The door shall be fastened to the enclosure with concealed hinges and shall be equipped with flush-type catches and locks. The Contractor shall equip cabinet doors exceeding 40 inches in height with vertical bolt three point locking mechanism. All locks shall be keyed alike. The panelboard trim shall have a removable hinge assembly, in addition to the door hinge, that allows work inside the enclosure without the need to remove the trim.

3. The panelboard shall be provided with an information label. The information label shall include the panelboard designation, voltage, phase, wires, and bus rating.

C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1,000 amperes per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide full flexibility of circuit arrangement.

2. Solid neutral bus bars, where required, shall be provided. Neutral bus shall have the same ampacity as the main bus, unless otherwise indicated. Ratings shall be in accordance with applicable standards.

3. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.

4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.

5. All bus shall be tin plated copper and shall extend the entire useable length of the panelboard, including spaces. Panelboards Listed and Labeled as a four-wire panel shall not be used in place of a three-wire panel where a neutral conductor does not exist in the supply conductors to that panel.

D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type and UL 489 Listed. All circuit breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation.

2. Circuit breakers used for lighting circuit switching shall be approved for the purpose and shall be marked “SWD” where required by Article 440 by the NEC. Circuit breakers installed for air conditioning units shall be HACR type.

3. Circuit breaker voltage rating shall meet or exceed the panelboard voltage indicated on the Drawings. Trip elements of circuit breakers shall be 20A, unless otherwise indicated on the Drawings. Circuit breakers shall have an interrupting rating at 480 VAC that matches the panelboard short circuit rating.

4. Main circuit breakers shall be individually mounted. Branch mounted circuit breakers are not acceptable unless specifically indicated on the panel schedules. Coordinate top or bottom mounting of main circuit breaker with incoming conduit location.

5. Where indicated on the Drawings, branch circuit breakers shall be provided with a padlockable hasp or handle padlock attachment for padlocking in the off position as required to meet the NEC requirement for disconnecting means and/or OSHA lock-out/tagout standard. Locking hardware shall remain in place even when the packlock is removed. Branch circuit breakers shall be provided with a similar lock-on device where indicated on the Drawings.

E. Directories

1. Approved directories with noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be provided in each panel. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Drawings, except as otherwise authorized by the Engineer.

2.05 COMBINATION POWER UNITS

A. Combination power units shall be installed as specified herein and indicated on the Drawings. The unit shall be a combination of a transformer and a lighting panelboard. Transformer rating, primary circuit breaker rating, secondary circuit breaker rating, and panelboard bus rating shall be as indicated on the Drawings. The transformer and panelboard shall meet the requirements for these products as specified herein and elsewhere in these Specifications.

B. Combination power units located outdoors shall be suitable for outdoor use and be provided in a NEMA 3R enclosure unless otherwise indicated on the Drawings.

C. Combination power units shall have all copper windings and terminations. The transformer shall be115°C temperature rise and epoxy resin encapsulated.

D. The combination power unit shall be a Mini-Power Zone as manufactured by the Square D Company, a Mini-Power Center as manufactured by Eaton, Servicecenter as manufactured by General Electric Company, or Siemens Energy and Automation, Inc. equivalent.

2.06 DC POWER SYSTEM PANELBOARD

A. The DC power system panelboard shall meet the requirements specified herein for the lighting panelboards with the following exceptions:

1. Circuit breakers shall have an interrupting rating at 250 VDC that matches the panelboard short circuit rating.

2.07 SURGE PROTECTIVE DEVICES

A. The panelboards shall be furnished with integrated Type II surge protective devices (SPD). SPDs shall be provided in the location and quantity as shown on the Drawings. SPD shall be installed within the panelboard enclosure in a location that allows the required quantity and rating of branch circuit breakers to be installed. Reducing the quantity of branch circuit breakers to less than that required by the panel schedules is not acceptable.

B. The SPD shall be rated, designed, tested, listed, and labeled in accordance with UL-1449, latest edition.

C. The SPD shall be factory installed by the panelboard manufacturer using a direct bus connection. There shall be no cable connection between the bus bar and the SPD device.

D. The SPD shall have a fault current rating equal to or greater than that of the fault current rating of the panelboard. The SPD shall employ metal-oxide varistor (MOV) technology. If integral fusing is used, the fuses shall allow the maximum rated surge current to pass without fuse operation.

E. The SPD shall have a maximum continuous operating voltage (MCOV) of at least 115% of the nominal voltage of the panelboard. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

SYSTEM VOLTAGE	L-N	L-G	L-L	N-G
208Y/120	700V	700V	1200V	700V
480Y/277	1200V	1200V	1800V	1200V
480 DELTA	N/A	1200V	2000V	N/A
240 DELTA	N/A	1200V	1200V	N/A
120/240	700V	700V	1200V	700V

F. The Nominal Discharge Current (In) of the SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.

G. The surge current rating for each SPD shall be as indicated on the Drawings. Surge current ratings are indicated in panel schedules. Surge current rating indicated is on a per phase basis.

H. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

SYSTEM CONFIGURATION	MODES OF PROTECTION	NUMBER OF MODES
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedance Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

I. The SPD shall be furnished with an audible alarm and silence pushbutton, integral SPD status LEDs (one per phase), and a Form C dry contact for remote indication of alarm. A surge counter shall also be provided.

J. The SPD equipment shall be SPD Series by Eaton, SurgeLogic by the Square D Company, Tranquell by the General Electric Company, Siemens Energy and Automation Inc. equivalent, or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Panelboards and combination power units shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer, and as required by NECA 407.

B. Panelboards shall be set true and plumb in locations as shown on the Drawings. The top of panelboard enclosure shall not exceed six (6) feet above finished floor elevation.

C. Enclosures shall not be fastened to concrete or masonry surfaces with wooden plugs. Appropriate cadmium plated or galvanized steel bolts shall be used with expansion shields or other metallic type concrete insert for mounting on concrete or solid masonry walls. Cadmium plated or galvanized steel toggle bolts shall be used for mounting on concrete block or other hollow masonry walls. Bolt diameter shall be as required considering the size and weight of the completed panelboard and enclosure to provide adequate structural support.

D. The Contractor shall not use factory furnished knockouts with surface mounted back boxes. The Contractor shall punch or drill required openings during installation and shall equip flush mounted back boxes with manufacturer's standard pattern of knockouts.

E. The Contractor shall install cabinets (and other enclosure products) in plumb with the building construction. Flush mounted enclosures shall be installed so that the trim will rest against the surrounding surface material and around the entire perimeter of the enclosure.

F. Bus loads in all panelboards shall be balanced between phases to within a tolerance of one (1) KVA. Convenience receptacles shall be distributed evenly among all phase buses as much as practical.

G. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Field Tests

a. Prior to termination of any conductors to the circuit breakers , all bus work and circuit breakers shall be tested from phase to phase and phase to ground with a 1000 VDC megaohmeter for 1 minute in accordance with NECA 407. Resistance values shall be recorded and shall not be less than 100 megohms.

b. Prior to terminating any wires to the circuit breakers, the resistance of the connection between the bus work and each circuit breaker shall be tested through the use of a low-resistance ohmmeter. Record the resistance values for each circuit breaker.

- END OF SECTION -

SECTION 16481

INDIVIDUAL MOTOR CONTROLLERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install separately mounted, individual motor controllers for 120 volt single phase, and 208 and 480 volt three phase motors as specified herein and indicated on the Drawings. Individual motor controllers specified in this Section include magnetic motor starters, manual motor starters, and reduced voltage solid state starters (RVSS).

B. Reference Section 16000, Basic Electrical Requirements; Section 16123, Low Voltage Cable; Section 16195, Electrical Identification; and Section 16902, Electric Controls and Relays.

1.02 CODES AND STANDARDS

A. Individual motor controllers shall be designed, manufactured, and/or listed to the following standards as applicable:

1. UL 508 – Standard for Industrial Control Panels

2. NEMA 250 – Enclosures for Electrical Equipment

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Spare Parts.

3. Reports of Certified Shop and Field Tests.

4. Operation and Maintenance Manuals.

5. Manufacturer's Field Startup Report.

6. Manufacturer's Representatives Installation Certification.

B. Each submittal shall be identified by the applicable specification section.

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1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

2. Product data sheets.

3. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of individual motor controller. For RVSS starters, in free-standing enclosures, show conduit stub-up area locations on the Drawings.

4. Custom wiring diagrams for each individual motor controller. Standard wiring diagrams that are not custom created by the manufacturer for the individual motor controllers for this project are not acceptable. One wiring diagram which is typical for an equipment group (e.g. blower) is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

5. Bill of material list for each individual motor controller.

6. Nameplate schedule for each individual motor controller.

7. Manufacturer’s installation instructions.

8. Time-current curves for each type and size protective device if requested by the Engineer.

9. Approximate total shipping weight of each RVSS.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for individual motor controller. These final drawings shall be plastic laminated and securely placed inside each individual motor controller unit door and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved with the equipment name and/or number with which it is associated. Equipment identification shall be in accordance with Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 INDIVIDUAL MAGNETIC MOTOR STARTERS

A. Individual magnetic motor starters shall be combination type complete with motor circuit protectors (MCP's). Starters shall be rated 480 VAC, 3-pole, sized for the intended load unless otherwise indicated. In no case shall a starter smaller than a NEMA Size 1 be used. Each starter shall be furnished with a minimum of two spare auxiliary contacts.

B. In non-hazardous locations, motor starters shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

C. In hazardous locations, motor starters shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

AREA CLASSIFICATION	ENCLOSURE TYPE AND MATERIAL
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 7, Die Cast Aluminum
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 9, Die Cast Aluminum

D. Starters shall be provided with all coils and controls for 120 VAC operation, unless otherwise indicated on the Drawings.

E. The motor controller manufacturer is advised to review the total Contract Documents for additional requirements for space heaters, power factor correction capacitors, and similar equipment which may not be specified in this Division or shown on the Drawings. Control power transformers shall be fused on both the primary and secondary sides. The minimum control power transformer VA requirements are as shown below. Control power transformers shall be sized as required for the connected loads, plus 25% spare capacity.

Size 1-150 VA
Size 2-150 VA
Size 3-200 VA
Size 4-300 VA
Size 5-500 VA

F. Each starter shall be supplied with a manual reset overload relay. Manual reset shall be accomplished by a door mounted overload reset pushbutton. The relays shall be solid state type, with at least one isolated normally open and one isolated normally closed auxiliary contact that operates when a trip condition has occurred. Relays shall be self-powered, have a visible trip indicator, have a trip test function, and have selectable Class 10 or 20 operation. Overload relays shall be set for Class 10 operation unless otherwise directed by the Engineer. Overload relay shall have phase loss protection built in to trip the unit and protect the motor against single phasing. The Contractor shall provide the overload relay model with the correct current range for each application. Overload relay shall have adjustable current range dial. Eutectic alloy and bi-metallic type overload relays are not acceptable.

G. Control Devices

1. Furnish and install control devices as required and/or shown on the Drawings. The following control devices shall be provided as specified in Section 16902, Electric Controls and Relays:

   a. Pilot devices (switches, indicating lights, etc.)

   b. Relays and timers

   c. Control Terminal blocks

H. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of unit; No. 12 AWG (minimum). Wiring shall be type MTW rated for 105ºC. Wire color coding shall be as specified in Section 16123, Low Voltage Cable.

I. Each motor starter coil shall be equipped with a surge-suppression device for protection of the solid state equipment (e.g. programmable logic controller) wired as part of the control circuit.

J. Individual magnetic motor starters shall be as manufactured by Eaton using NEMA rated Freedom Series starters and contactors, the Square D Company equivalent, GE/ABB equivalent, or Siemens Energy & Automation, Inc. equivalent.

2.03 INDIVIDUAL MANUAL MOTOR STARTERS

A. Individual manual motor starters in enclosures as specified above shall be furnished and installed for outdoor and indoor exposed work. Furnish and install manual motor starters in outlet boxes with flush wall plates as required for concealed work.

B. Furnish and install manual motor starters with pilot lights and overload heater elements of correct rating based on motor nameplate data.

C. Manual motor starters shall be equipped with either a push button or toggle operator with reset device or mechanism accessible without opening the enclosure.

D. Individual manual motor starters for motors one (1) horsepower and less shall be Eaton Type MS, the Square D Company equivalent, Allen-Bradley equivalent, or Siemens Energy & Automation, Inc. equivalent.

E. Individual manual motor starters for integral horsepower motors shall be Eaton Type B100 or B101, the Square D Company equivalents, Allen-Bradley equivalent, or Siemens Energy and Automation, Inc. equivalents.

2.04 REDUCED VOLTAGE SOLID STATE STARTER

A. The solid-state reduced-voltage starter shall be UL Listed. The solid-state reduced-voltage starter shall be an integrated unit with power SCRs, logic board, an integral paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing. The starter shall meet all applicable requirements of this Section and other sections in this Division.

B. The RVSS shall be suitable for continuous operation at 115% of its continuous ampere rating. The Contractor is fully responsible for the review of the mechanical specifications to determine specified motor speed, horsepower and full load amperes. This information is available in the applicable mechanical specifications for each piece of equipment (e.g. backwash blower).

C. The RVSS shall be suitable for the following environmental conditions:

1. Operating Temperature: 0-50 degrees C

2. Humidity: 0-95 percent non-condensing.

3. Altitude: up to 3,300 feet.

D. The RVSS shall be suitable for operation on a 480 VAC, 3-phase, 60 Hertz system.

E. The SCR-based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 1500 volts PIV. Units using triacs or SCR/diode combinations are not acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt effects.

F. The paralleling run bypass contactor shall energize when the motor reaches full speed and close/open under one (1) times motor current.

G. The starter shall be provided with electronic overload protection as standard and shall be based on an inverse time-current algorithm. Overload protection shall be capable of being disabled during ramp start for long acceleration loads via a DIP switch setting on the device keypad. Overload protection shall be adjusted via the device keypad and shall have a motor full load ampere adjustment from 30 to 100% of the maximum continuous ampere rating of the starter. The starter shall have selectable overload class setting of 5, 10, 20 or 30 via a DIP switch setting on the device keypad. The starter shall be capable of either an electronic or mechanical reset after a fault. Units using bimetal or eutectic alloy overload relays are not acceptable.

H. The starter shall provide protection against the following conditions:

1. Improper line-side phase rotation. The starter shall stop the motor load if a line-side phase rotation other than A-B-C exists.

2. Phase loss or unbalanced conditions. The starter shall stop the motor load if a 50% current differential between any two phases is encountered.

3. Motor stall conditions.

4. Motor jam conditions.

I. The starter shall be provided with a form C normally open (NO), normally closed (NC) contact that shall change state when a fault condition exists. The contacts shall be rated 60 VA (resistive load) and 20 VA (inductive load). In addition, an LED display on the device keypad shall indicate the type of fault (Overtemp, Phase Loss, Jam, Stall, Phase Reversal, and Overload).

J. The starter shall be provided with an unpowered internal “Run” contact rated for 24VDC or 120 VAC operation.

K. The starter shall be provided with an Ethernet Port (RJ-45) to connect to the plant's SCADA system and provide all available status monitoring outputs from the RVSS to the SCADA system (e.g. run, fault, voltage, current, power, power factor, etc.). The Ethernet Port connection is in addition to any hard-wired connections shown on the Contract Drawings or indicated within Division 17.

L. The following control function adjustments on the device keypad shall be provided:

1. Selectable Torque Ramp Start or Current Limit Start

2. Adjustable Kick Start Time, 0-2 seconds

3. Adjustable Kick Start torque, 0-90%

4. Adjustable Ramp Start Time; 0.5-180 seconds

5. Adjustable Initial Starting Ramp Torque; 0-100%

6. Adjustable Smooth Stop Ramp Time; 0-60 seconds.

M. Enclosed units shall include a thermal-magnetic circuit breaker for short-circuit protection and quick disconnect means. If required, the unit shall include a 24 VDC power supply to be used as the primary control voltage source. A 120 VAC control power transformer, fused on both the primary and secondary sides, shall be provided as an additional control power source to power such devices as motor space heaters, solenoid valves, and similar control elements as required. Input and output isolation contactors shall be furnished as indicated on the Drawings.

N. Unless otherwise specified or indicated on the Drawings, the RVSS enclosure shall be dead-front, with front accessibility. The enclosure shall be designed for both bottom and top entry. The enclosure shall be designed so rear access is not required for operations, maintenance, and repair tasks. The doors shall have full length piano type hinges and shall be braced to prevent sag when fully open. Other enclosure requirements are:

1. For standalone RVSSs, finish exterior of the enclosures in ANSI-61 gray enamel or furnish in a color to match the complete line-up of equipment as indicated on the Drawings and accepted by the Engineer.

2. RVSS integrated into motor control center structures shall meet the requirements of the enclosure in which it is installed.

3. The Contractor shall reference the Drawings for maximum dimensions of the RVSSs. This is especially critical for the RVSSs controlling the blowers.

O. In non-hazardous locations, the RVSS shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 3R, Painted Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 3R, Painted Steel

P. The complete starter assembly shall be rated per UL 508 for a minimum withstand rating of 65kAIC rms. Starters enclosed in motor control centers shall be by the same manufacturer.

Q. Control Devices

1. Furnish and install control devices as required and/or shown on the Drawings. The following control devices shall be provided as specified in Section 16902, Electric Controls and Relays:

a. Pilot devices (switches, indicating lights, etc.)

b. Relays and timers

c. Control Terminal blocks

R. The reduced voltage solid state starter shall be the SMC-Flex with integral bypass as manufactured by Allen-Bradley, Eaton equivalent, the Square D Company equivalent, GE/ABB equivalent, or Siemens Energy and Automation, Inc. equivalent.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All individual motor starters shall be installed as indicated on the Drawings and as recommended by the equipment manufacturer.

B. Individual motor starters shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

a. None required.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA acceptance testing specifications, latest edition.

3.03 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's factory-trained technical representative who shall adequately supervise the installation and startup of the RVSS equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

B. The manufacturer's technical representative shall perform all startup and field acceptance testing as specified herein.

C. The Contractor shall provide training for the Owner's personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner's personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of two (2) hours each. Training shall not take place until after the motor controllers have been installed and tested. Training shall be conducted at times coordinated with the Owner.

D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of two (2) working days during installation of the motor controllers.

2. One (1) trip of two (2) working days to perform startup and field acceptance testing of the motor controllers.

3. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify any issues to be corrected under warranty.

4. One (1) trip of one (1) working day to perform training as specified herein.

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

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SECTION 16482

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation, new motor control buckets located in the existing motor control centers as specified herein and indicated on the Drawings.

B. The MCC electrical scope of work for this project primarily includes, but is not limited to, the following:

1. Remove existing RVSS starters for existing mixers in existing MCCs.

2. Furnish and install new full voltage non-reversing (FVNR) starters for new mixers to be placed in existing MCC buckets where previous starters were removed.

3. Furnish and install associated starter control logic and associated devices for a complete and operable system.

4. Other electrical work as specified herein and indicated on the Drawings.

C. The Contractor shall obtain the motor control center components from one manufacturer who shall also manufacture all major equipment components, which includes, but is not limited to, combination starters, reduced voltage solid state starters, circuit breakers, power monitoring equipment, and other components of the equipment assembly. Subcontracting of wiring is not acceptable.

D. The motor control center components shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

E. Reference Section 16000, Basic Electrical Requirements; Section 16195, Electrical Identification; and Section 16902, Electric Controls and Relays.

1.02 CODES AND STANDARDS

A. The assemblies shall meet or exceed the requirements within the following standards for motor control centers:

1. NEMA ICS-18

2. UL845

B. The motor control center components shall be designed, manufactured, and tested in facilities registered to the following quality standards:

1. ISO 9001

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Proposed Testing Methods and Reports of Certified Shop and Field Tests.

3. Manufacturers Startup Certification

4. Operation and Maintenance Manuals.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for each motor control center bucket shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

2. Product data sheets.

3. Example equipment nameplate data sheet.

4. Approximate total shipping weight of each bucket.

5. Plan, front, and side view drawings, including overall dimensions of each bucket. Identify shipping splits and show conduit stub-up area locations on the Drawings.

6. Internal schematic and point-to-point wiring diagrams of each motor control unit including full voltage solid state starters integrated into the motor control center. Standard wiring diagrams that are not custom created by the manufacturer for the motor control centers for this project are not acceptable. One wiring diagram which is typical for an equipment group (e.g. mixer) is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

7. Bill of material list for each motor control unit.

8. Nameplate schedule for each motor control unit.

9. Manufacturer's installation instructions.

10. Manufacturer’s Warranty Statement

11. Table listing all motor loads connected to the new buckets in the motor control center. Table shall include the full load amps of the APPROVED motors. Final approval of MCC shop drawings cannot be given until all motor loads for the new MCC buckets have been reviewed, approved, and shown in this table.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each motor control center unit of each motor control center bucket. These final drawings shall be included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. It is the intent of these specifications that all components of the motor control center be provided by one manufacturer who shall have the sole responsibility of matching all components and providing equipment which functions together as a system. The manufacturer of the motor control center shall also be the manufacturer of the motor controllers. The use of third-party supply and assembly of these components is not acceptable.

C. Motor control centers modifications shall utilize existing manufacturer's equipment. Replacement starters shall be as manufactured by Square D. Replacement buckets shall be UL listed and labeled, and installation of new equipment shall not void the UL listing of the MCC. No alternatives to this requirement will be accepted.

2.02 MOTOR CONTROL CENTER

A. General

1. The enclosures shall be cleaned, primed, and finish coated in accordance with the manufacturer's standard process. The pre-treatment process shall be a zinc chromate primer followed by a "One Coat" paint process that is monitored to meet the manufacturer's specifications for paint color, texture, thickness, and durability. Enclosure interior and exterior finish color shall be ANSI 49 (medium light gray). The color of the back panel/bucket located within the MCC enclosure shall be white.

2. The motor control centers shall be capable of withstanding the fault current available at its line terminals. Minimum bus bracing, withstand, and interrupting ratings are specified herein.

3. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of unit; No. 12 AWG (minimum). Wiring shall be type MTW rated for 105□C. Wire color coding shall be red for control and black for power. Wire numbers shall not be repeated in a motor control center.

4. Starter units shall contain the number of auxiliary contacts, unit-mounted pilot devices and indicating lights, control relays, elapsed time meters, and other devices as shown on the Drawings and required for the applications. A minimum of two (2) normally open (NO) and two (2) normally closed (NC) spare contacts shall be provided for each magnetic starter. These spare contacts shall be shown on the submittal wiring diagrams.

B. The Unit Compartments

1. Each unit compartment shall be provided with an individual front door hinged to the vertical structure. Each plug-in unit shall be supported and guided by a removable unit support pan, so that the unit rearrangement is easily accomplished. The rearrangement of the unit support pan from one location to the other shall be accomplished without use of tools. After insertion, each plug-in unit shall be held in place by at least one multi-turn latch, located at the front of the unit. The latch shall be located for front accessibility and installation convenience. An additional

mechanical interlock shall be provided to prevent withdrawal of the unit from the stationary structure with the operating mechanism in the ON position.

2. The unit plug in power stabs shall be electromagnetically tin plated copper to yield a low resistance connection and designed to tighten during heavy current surges and short circuits. The stab shall be backed by spring steel clips to provide and maintain a high pressure, two point connection to the vertical bus. They shall be free floating and self-loading plug-in. Wiring from the unit disconnecting means to the plug-in stab shall be exposed at the rear of the unit. The power cable terminations at the plug-in stab shall be mounted in a two-piece, glass polyester support assembly. This support assembly shall provide a separate isolated pathway for each phase, minimizing the probability of a unit fault condition reaching the power bus system.

3. NEMA Size 1 through Size 5 non-reversing starters shall be plug-in units. Size 1, 2, and 3 shall utilize stab assembly rated 100A. Stab assemblies for Size 4 and Size 5 starters shall be rated for the starters maximum output current rating.

4. An industrial, heavy-duty flange handle mechanism shall be supplied for the control of each disconnecting means. This mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position. The operator handles shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8 inch diameter shackle padlocks and in the "ON" position with one (1) 3/8 inch diameter shackle padlock.

5. The operator handle of all units shall be interlocked with the door units so that the disconnect means cannot be switched unless the door unit is closed. A means shall be provided for purposely defeating the interlock during maintenance or testing. This interlock shall also prevent opening the unit door unless the disconnecting means is in the off position. An externally operated defeater requiring the use of a screwdriver shall provide access to the unit without interrupting service.

6. The overload relays shall be resettable from the outside of the enclosure by means of an insulated bar or button.

C. Combination Motor Control Units

1. Motor branch circuits shall be protected by a motor circuit protector (MCP).

2. The motor circuit protector shall be operated by a toggle type handle and shall have a quick make, quick break overcenter switching mechanism that is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits and abnormal currents. Tripping shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. All latch surfaces shall be ground and polished. All poles shall be so constructed that they open, close, and trip simultaneously.

3. Each pole of these motor circuit protectors shall provide instantaneous short circuit protection by means of an adjustable magnetic only element.

4. The motor circuit protectors in combination with a contactor and overload relay shall have an interrupting rating that matches the motor control center short circuit rating at 480V.

5. Motor circuit protector's ratings, modifications, etc., shall be as specified herein and as indicated on the Drawings.

6. Motor circuit protectors shall be completely enclosed molded case devices with a current sensing coil in each of the 3 poles and have a magnetic trip adjustment located on the front. The motor circuit protector shall be manually operable. The protector shall be designed to meet the NEC requirement concerning motor full load and locked-rotor current. Ampere ratings shall be clearly visible. Contacts shall be of non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes, consisting of metal grids mounted in an insulating support.

D. Motor Starters

1. Motor starters shall conform to NEMA Standard IC1 and shall be for across-the-line starting, unless otherwise indicated. IEC rated equipment is not acceptable and shall be used as a basis for rejection of the equipment. The size of the starter shall be as required for the particular load. Minimum starter size shall be NEMA Size 1. Size 1 and 2 starters shall be completely drawout type, so that units may be withdrawn without disconnecting any wiring. Size 3 and 4 full-voltage, non-reversing starters shall be drawout type after disconnecting power leads only. Starters over three-space units high may be bolt-on type. A positive guidance system shall be provided to assure proper alignment of wedge-shaped power stabs in deadfront openings in vertical power bus.

2. A suitable control disconnect device(s) to comply with the requirements of the NEC shall be provided.

3. Magnetic starters and contactors shall be electromagnetic vertical or horizontal lift design with double break cadmium oxide silver contacts. Design shall meet or exceed the requirements of UL and NEMA Standards. Coils shall be hot molded construction to protect the coils from mechanical and environmental damage.

4. Each starter shall be able to accommodate a minimum of three (3) auxiliary contacts in addition to the hold-in contact.

5. Each starter shall be supplied with a 3 pole, manual reset overload relay. The relays shall be solid state type, with at least one isolated normally open and one isolated normally closed auxiliary contact that operates when a trip condition has occurred. Relays shall be self-powered, have a visible trip indicator, have a trip test function, and have selectable Class 10 or 20 operation. Overload relays shall be set for Class 10 operation unless otherwise directed by the Engineer. Overload relay shall have phase loss protection built in to trip the unit and protect the motor against single phasing. The Contractor shall provide the overload relay model with the correct current range for each application. Overload relay shall have

adjustable current range dial. Eutectic alloy or bi-metallic type overload relays are not acceptable.

6. Each motor starter coil shall be equipped with a surge-suppression device for protection of the solid state equipment (e.g. programmable logic controller) wired as part of the control circuit.

7. The Contractor and motor control center manufacturer is advised to review the Contract Documents for additional requirements for space heaters, power factor correction capacitors, and similar equipment which may not be specified in this Division or shown on the Drawings. Control power transformers shall be fused on both the primary and secondary sides. The minimum control power transformer VA requirements are shown below. Control power transformers shall be sized as required for the connected loads, plus 25% spare capacity.

   a. Size 1-75 VA

   b. Size 2-75 VA

   c. Size 3-200 VA

   d. Size 4-300 VA

   e. Size 5-500 VA

8. Reduced voltage solid state starters shall be provided for the motor loads as specified herein and as indicated on the Drawings.

E. Terminal Blocks

1. Terminal blocks associated with removable units within the motor control center shall be provided as follows:

   a. Terminal blocks shall be mounted within the unit insert and in the front for ease of accessibility.

   b. Pull-apart style terminal block assemblies shall be provided. Terminal block assembly shall consist of a male and female component held together with captive screws. The terminal block assembly shall be designed to withstand the effects of vibration, yet able to be pulled apart without difficulty. The terminals of the assembly shall be recessed to isolate them from accidental contact. Terminal markings shall be provided for the purpose of identifying terminations. Terminal strips shall be suitable for use as a disconnecting means of foreign interlock voltages.

   c. For starters Size 2 and smaller, terminate all starter wiring (power and control) and external field wiring on terminal blocks provided in each unit.

   d. For starters Size 3 and larger, terminate control wiring and external field control wiring on terminal blocks provided in each unit.

2. Terminal blocks associated with non-removable units within the motor control center shall be provided in accordance with Section 16902, Electric Controls and Relays.

3. Provide a minimum of four (4) spare terminals in each terminal block assembly.

F. Control Devices

1. Furnish and install control devices as required and/or shown on the Drawings. The following control devices shall be provided as specified in Section 16902, Electric Controls and Relays:

a. Pilot devices (switches, indicating lights, etc.)

b. Relays and timers

G. Nameplates

1. Provide engraved plastic nameplates to identify the motor control center, each unit compartment, door mounted devices, and internal components.

2. Nameplates shall be as specified in Section 16195, Electrical - Identification. Equipment names and numbers as indicated on the single line diagrams shall be used as the basis to engrave the nameplates.

3. Provide a master nameplate giving motor control center designation, voltage rating, ampere rating, short circuit rating, manufacturer's name, general order number and item number.

4. Control components mounted as part of the assembly, such as fuse blocks, control relays, pushbuttons, switches, and similar devices, shall be suitably marked for identification corresponding to appropriate designations on the manufacturer's wiring diagrams.

H. Blank Door Requirements

1. Provide new solid, blank doors for any unused space in the modified motor control center as indicated on the Drawings.

I. Motor Control Center Modifications

1. The Contractor shall modify existing motor control centers and specific motor control center units as specified herein and indicated on the Drawings. These modifications include, but are not limited to, additions of door mounted pilot devices, modifications to existing motor control circuits and other work.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The motor control center buckets shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

B. Install motor control centers to allow complete unit door swing required for unit removal. This is specifically required where a vertical section of motor control center is set next to a wall to the left of the motor control center section.

C. Where motor control center structures are located away from walls to allow bottom conduit entry, the Contractor shall furnish and install sheet metal coverings for openings along the sides and top of the motor control center line-up. The purpose of the coverings is to minimize dust, dirt, and undesirable materials from collecting behind the equipment. The sheet metal coverings shall be of the same material, gauge, and finish as the motor control center.

D. Motor control centers shall be furnished with anchor bolts as required for aligning and mounting. Floor channels with end covers shall be of type recommended by the manufacturer and shall be furnished for installation in a concrete pad.

E. All field wiring that is terminated directly to a unit within the motor control center shall be neatly routed in a manner that does not hinder the ability to service, adjust, or replace components within that unit. Field wiring shall be properly anchored to the motor control center and individual unit structures.

F. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

a. None required.

2. Certified Shop Tests and Reports

a. Submit description of proposed testing methods, procedures, and apparatus. Submit notarized and certified copies of all test reports.

b. As a minimum, the entire motor control center shall go through a quality inspection before shipment. This inspection shall include, but is not limited to, the following:

i. Physical inspection of the structure and the electrical conductors including bussing, general wiring, and units.

ii. General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.

iii. AC dielectric tests of the power circuits and control circuits.

iv. Markings/labels, including instructional type, Underwriters Laboratory (UL), and inspector's stamps.

3. The manufacturer shall use integral quality control checks throughout the manufacturing process to maintain the correctness of the motor control center.

B. Field Tests

2. Field tests shall be performed in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

3.03 FIELD ADJUSTMENTS

A. All adjustable settings of circuit breakers shall be set in the field by a qualified representative of the manufacturer, or an outside testing company retained by the Contractor, in accordance with the settings designated in the coordination study. See Section 16000, Basic Electrical Requirements.

B. The settings of the motor circuit protectors and overload relays shall be set based on the coordination study and the motor nameplate data of the motors installed.

3.04 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified, factory-trained manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

B. The manufacturer’s technical representative shall perform startup and functional testing of the equipment as specified herein.

C. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of one (1) working day during the installation and startup of the equipment.

2. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify any issues to be corrected under warranty.

D. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

- END OF SECTION -

SECTION 16497

GENERATOR TERMINATION CABINET

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test and place in satisfactory operation generator termination cabinets as specified herein and indicated on the Drawings.

B. Generator termination cabinets shall be configured for use with a temporarily connected standby/generator source (utilizing cables with cam-style connectors) as specified herein and indicated on the Drawings.

C. The generator termination cabinets shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

D. Reference Section 16000 – Basic Electrical Requirements; Section 16123 – Low Voltage Wire and Cable; Section 16195 – Electrical Identification; and Section 16902 – Electric Controls and Relays.

1.02 CODES AND STANDARDS

A. Generator termination cabinets and their components shall be designed, manufactured, and/or listed to the following standards as applicable:

1. Underwriters Laboratories

a. UL 1008 – Transfer Switch Equipment

b. UL 1691 – Single Pole Locking-Type Separable Connectors

2. National Electrical Code (NEC)

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300 – Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Special Tools List

4. Reports of Certified Shop Tests

5. Guarantee/Warranty Program

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.

C. Shop drawings for each generator termination cabinet shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

2. Product data sheets.

3. Complete assembly, layout, and installation drawings with clearly marked dimensions and conduit entrance locations.

4. Example equipment nameplate data sheet.

5. Complete internal schematic and interconnecting wiring diagrams.

6. Nameplate schedule.

7. Manufacturer's standard installation instructions.

8. Manufacturer's written warranty.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each generator termination cabinet. These final drawings shall be plastic laminated and securely placed inside each termination cabinet and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 IDENTIFICATION

A. Each generator termination cabinet shall be identified with the identification number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each enclosure. Nameplates shall be as specified in Section 16195 – Electrical - Identification.

1.07 WARRANTY

A. The manufacturer shall warrant each generator termination cabinet for a minimum of five (5) years from date of shipment. In addition, the manufacturer shall repair or replace equipment found faulty under the terms of the warranty. The manufacturer shall submit data outlining the guarantee/warranty program.

1.09 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The equipment described herein, as a minimum, shall meet all the requirements specified in this Section and shall be a product of a manufacturer who has produced generator termination cabinets for a period of at least three (3) years. The equipment shall be compatible with the loads to be served. Assembly of the cabinet by a fabricator is not acceptable.

C. The generator termination cabinets shall be Listed by Underwriters Laboratories, Inc. to standard UL-1008, with a minimum short circuit current rating of 42kA or, as indicated on the Drawings. The equipment shall be capable of withstanding the fault current available at its line terminals. Enclosures shall have ampere ratings and number of poles as indicated on the Drawings and shall be suitable for 480VAC, three-phase, 60Hz operation.

D. The generator termination cabinets shall be TempTap Inlet Box Series as manufactured by ESL Power Systems Inc. or approved equal.

2.02 GENERATOR TERMINATION CABINET

A. Design Requirements

1. Generator termination cabinets shall consist of cam-style male connectors (for connection of portable generator cables), power distribution block(s), and grounding provisions all housed within a padlockable enclosure.

2. The enclosure shall be NEMA 3RX rated and fabricated from Type 304 stainless steel suitable for pad-mounting. The enclosure shall have provisions for top, bottom, and side conduit/wire entry (for permanently installed conductors), and shall meet or exceed the UL-1008 minimum wire bending space requirements.

3. The enclosure shall be dead-front with a hinged main access door that extends the full height of the enclosure. The main access door shall also include a lockable hinged cover to prevent unauthorized access.

4. The enclosure shall include a dead-front hinged inner door which allows for access to the cable connection compartment by opening the main access door without exposing the live parts.

5. Access for connection of portable generator cables with cam-style female plugs shall be via drawn flange cable entry openings in the bottom of enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected. The hinged flap door shall allow cable entry only after the main access door has been opened.

6. The cable connection compartment shall include single-pole separable type cam-style male connectors each rated for 400A at 600VAC. The cam-style connectors shall be Listed by Underwriters Laboratories, Inc. to standard UL-1691. The connectors shall be color coded and shall be provided for each phase, neutral (if required), and ground. Each of the phase connectors shall be factory-wired to the power distribution block. The ground connector(s) shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. The neutral connector(s), if required, shall be factory wired to a power distribution block. Parallel sets of connectors shall be provided in the quantity required to achieve the total current rating as indicated on the Drawings.

B. Controls and Accessories

1. All factory-installed wiring shall have color coded insulation and shall be provided with heat shrink identification tags at both ends in accordance with Section 16123 – Low Voltage Wire and Cable. Control wiring shall be No. 14 AWG (minimum). Power wiring shall be sized to suit the application; No. 12 AWG (minimum). Wiring shall be type MTW rated for 105°C.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Each generator termination cabinet shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

B. The generator termination cabinet shall be provided with adequate lifting means for installation of pad mounted enclosures.

C. The Contractor shall tighten all assembled bolted connections to the manufacturer's torque recommendations prior to energizing.

D. Install each enclosure to allow complete door swing required for component removal.

E. The Contractor shall coordinate conduit/wire entry into the enclosure with the manufacturer. Where located outdoors, conduits shall not enter the top of the enclosure.

F. Conduit entry into the generator termination cabinets shall be provided by the Contractor. Contractor shall furnish and install listed, watertight, conduit hubs (MYERS, T&B, or equal) for each conduit entry into the box (for load side connections to the Blower Switchboard. Hubs shall be properly installed and tightened to maintain Type 3RX integrity of the enclosure.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

a. None.

2. Certified Shop Tests and Reports

a. Generator termination cabinets shall be given routine factory tests. The factory tests shall demonstrate that the completed enclosures function correctly and meet applicable UL-1008 performance requirements (such as temperature rise).

b. Manufacturer shall submit certified test reports.

3. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000 – Basic Electrical Requirements.

b. Prior to energizing generator tap box, the Contractor shall perform the following checks and tests as a minimum:

1. Verify mounting and connections are complete and secure.

2. Verify internal components and wiring are secure.

3. Perform continuity check of all circuits.

4. Perform 1,000 VDC megger test on phase and ground cables.

5. Verify deadfront is secure.

6. Confirm operation of the generator tap box ground receptacle by attaching a plug to the generator tap box ground receptacle and then verify that the plug is grounded to the facility ground.

c. Other field tests as recommended by the termination cabinet manufacturer.

d. Prior to acceptance of the installation, load test the equipment with all available plant load, but do not exceed the generator's or generator termination cabinet's nameplate rating. Correct defects which become evident during this test.

3.03 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations.

B. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of one (1) working day during installation of the equipment for <u>each</u> generator termination cabinet.

2. One trip of one (1) working day after acceptance of the equipment.

3. One trip of one (1) working day during the warranty period.

C. The technician shall be on duty at the site for at least 8 hours per day and shall be available 24 hours per day when required to advise concerning special problems with equipment and systems.

D. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

- END OF SECTION -

SECTION 16500

LIGHTING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install all lighting fixtures, labor, and material, in accordance with the preceding Specifications, the requirements of this Section, and as shown on the Drawings.

B. Lighting shall be in accordance with the latest requirements of the Illuminating Engineering Society, and all lighting fixtures shall have the Underwriters Laboratories, Inc. label of approval.

C. All wiring shall be placed in conduit and shall comply with the Specifications for conduit, outlet boxes, pull and junction boxes, wires and cables, grounding, and other Sections as set forth in these Specifications and as noted herein.

D. Reference Section 16000, Basic Electrical Requirements, and Section 16170, Grounding and Bonding.

1.02 CODES AND STANDARDS

A. The equipment specified herein shall comply with the following codes and standards, where applicable.

1. Underwriter's Laboratories, Inc. (UL):

a. UL 924 – Emergency Lighting and Power Equipment

b. UL 935 – Fluorescent Lamp Ballasts

c. UL 844 – Luminaires for Use in Hazardous (Classified) Locations

d. UL 1029 – High Intensity Discharge Lamp Ballasts

e. UL 1598 – Luminaires

2. American National Standards Institute (ANSI):

a. ANSI C82.11 – High Frequency Fluorescent Lamp Ballasts

b. ANSI C62.41 – Guide for Surge Voltages in Low-Voltage AC Power Circuits

3. National Electrical Code (NEC), latest edition.

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1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts Lists

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Catalog cuts for each fixture type showing performance and construction details of standard fixtures, and complete working drawings showing all proposed construction details of special or modified standard fixtures.

3. Photometric curves.

4. Lamp and LED data including efficiency (Efficacy lumens/watt) information.

5. LED Driver information

6. Catalog data including applicable coefficients of utilization tables, isolux chart of illumination on a horizontal plane, beam efficiency, horizontal and vertical beam spread, and beam lumens.

7. Manufacturer’s warranty information

8. Custom wiring diagrams for each individual lighting contactor. Standard wiring diagrams that are not custom created by the manufacturer for the individual lighting contactors for this project are not acceptable. One wiring diagram which is typical for all lighting contactors is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate <u>all</u> devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

9. System (entire fixture assembly) efficiency data.

D. Shop drawings shall be submitted to the Engineer for review and acceptance for all fixtures before fixtures and poles are manufactured. Substitutions will be permitted only if acceptable to the Engineer.

E. Manufacturer's catalog number and description in the fixture schedule on the Contract Documents establishes a level of quality, style, finish, etc. The use of a catalog number describing the various types of fixtures shall be used as a guide only, and does not exclude all the required accessories or hardware that may be required for a complete installation.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit Operation and Maintenance Manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 WARRANTY

A. The manufacturer's warranty shall in no event be for a period of less than five (5) years from date of delivery of fixtures to the project site and shall include repair labor, travel expense necessary for repairs at the jobsite, shipping costs, expendables used during the course of repair, or complete replacement of the failed lighting unit.

B. Warranty for LED fixtures shall be provided for the entire fixture and shall include all parts and accessories. Warranty for non-LED fixtures shall be provided for the entire fixture and shall include all parts and accessories except the replaceable bulb. Submittals received without written warranties as specified shall be rejected in their entirety.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 FIXTURES

A. Each fixture shall bear the Underwriters Laboratories, Inc. label. All lighting fixtures shall be furnished complete with lamps of the size and type as indicated on the Drawings and all fittings and hardware necessary for a complete installation. Lighting fixtures shall have all parts and fittings necessary to completely and properly install the fixtures.

B. Fixture leads shall be as required by NEC and shall be grounded by the equipment grounding conductor in the conduit.

C. All glassware shall be high quality, homogeneous in texture, uniform in quality, free from defects, of uniform thickness throughout, and properly annealed. Edges shall be well rounded and free from chips or rough edges.

D. Emergency fixtures shall be UL 924 listed and have a minimum 90 minutes battery back-up.

E. Fixtures for use in hazardous locations shall be UL 844 Listed.

F. Fixtures specified to be damp or wet locations rated shall be UL 1598 listed.

G Fixtures shall be as specified in the fixture schedule below.

FIXTURE TYPE	LAMP/ FIXTURE WATTAGE	DESCRIPTION	MFR AND MODEL
EW1	10	Wall mounted, emergency fixture, 120-277 VAC with 6 or 12 VDC nickel cadmium battery, gray corrosion and impact resistant molded thermoplastic housing, time delay shutoff, surge and brown-out protection, and low voltage battery cut-off. Battery shall be suitable for 90 minutes (including all remote heads as shown on Drawings).Two 1.9W LED lamp heads, wet location Listed.	Holophane Desoto M90X, Philips Rhyno Series, or Lithonia INDX Series.
XW1	1.5W	Wall-mounted, green LED exit sign, 120-277VAC, brushed aluminum faceplate, die cast aluminum housing, single/double face as indicated on the drawings, nickel cadmium battery with self-diagnostics, brownout and surge protected, damp location Listed.	Holophane Magellan MEX Series, Lithonia LE Series, or Duallite Sempra Series.
LC1	78W (max)	Ceiling-mounted, 120-277VAC, LED light fixture, color temperature of 4100K, lineal ribbed frosted acrylic lens, spread distribution, gasketed fiberglass housing, stainless steel latches, 4ft, 10000 lumen minimum, and wet location Listed.	Holophane EMS LED Series, Cooper Vaportite LED Series, or Lithonia FEM LED Series.
LW1	39W (max)	Wall-mounted, 120-277VAC, LED light fixture, color temperature of 4000K, prismatic borosilicate glass lens, 10 LEDs, IESNA Type III medium distribution, gray die-cast aluminum housing, 1000mA driver, 3300 lumen minimum, integral photocell, and wet location Listed.	Holophane W4G LED, Hubbell LED PGM3 Series, or GE EWS1 Series.

2.03 LED DRIVERS

A. Drivers shall have a voltage range of (120-277) +/- 10% at a frequency 60Hz.

B. All drivers shall be designed to a power factor >90% with a total harmonic distortion THD <20% at full load.

C. Case temperature shall be rated for -40°C through +80°C.

D. Drivers shall have overheat protection, self-limited short circuit protection and overload protected.

E. Drivers shall be furnished with a fused primary.

F. Drivers shall have an output current ripple <30%

G. Drivers shall be manufactured by Advance, Universal or equal.

H. Drivers shall be UL Listed for damp location, UL1012, UL935, ROHS.

I. Drivers shall meet FCC 47 Sub Part 15.

J. All drivers shall be provided with ANSI/IEEE C62.41 Category C (10kV/5kA) surge protection.

2.04 LEDs

A. Luminaires provided with LED technology shall utilize high brightness LEDs with a group binning code of P and/or Q.

B. Color Temperature: as specified in fixture schedule.

C. Junction point shall be designed and manufactured to allow adequate heat dissipation.

D. LEDs shall be rated for 50,000 hours of life, minimum (based on IESNA L70).

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Lighting fixtures shall be located symmetrically with building lines as shown on the Drawings. The Contractor shall furnish and install the lighting fixtures to allow "convenient" access for maintenance such as cleaning, relamping, and other activities. The fixtures shall be installed to be accessed by a 12 ft. (max.) ladder. Where fixtures are shown in locations on the Drawings where maintenance would be difficult, the Contractor shall notify the Engineer for direction.

B. The Contractor shall provide and install all inserts, conduit, structural supports as required, lamps, ballasts, poles, wiring, and any other items required for a complete system. Contractor shall properly adjust and test, to the satisfaction of the Engineer, the entire lighting system. The Contractor shall provide pigtails and flexible conduit connected to an outlet box where necessary or required resulting in a neat and complete installation.

C. The Contractor shall protect all fixtures at all times from damage, dirt, dust, and the like. Before final acceptance, all fixtures and devices shall be cleaned of all dust, dirt or other material, be fully re-lamped (except LED fixtures) and in operating condition to the satisfaction of the Engineer.

D. The Contractor shall furnish and install all pendant trapezes and pendant stem hangers with durable swivel or equivalent trapeze hanger permitting normal fixture motion and self-alignment. Fixture pendants shall be Appleton Type UNJ ball type flexible hanger at the fixture and supports from an Appleton JBLX junction box with JBLX hub cover, or equal. Pendant lengths shall be adequate and adjusted to provide uniformity of installation heights above the reference datum. Stems shall be one-piece, with matching canopies and fittings.

E. Fixtures located on the exterior of the building shall be provided with neoprene gasket and non-ferrous metal screws finished to match the fixtures.

F. The finish or exposed metal parts of lighting fixtures and finish trims of all recessed lighting fixtures shall be as directed by the Engineer.

G. The Contractor shall furnish and install recessed fixtures with a separate junction box concealed and located as to be accessible when fixture is removed.

H. The Contractor shall furnish and install all boxes for lighting fixtures such that the box is not the sole support of the fixture. The boxes shall be offset to allow maintenance such that access to wiring within the box can be attained without having to consider supporting (holding) the fixture.

I. All lighting units, when installed, shall be set true and be free of light leaks, warps, dents, and other irregularities. All hangers, cables, supports, channels, and brackets of all kinds for safely erecting this equipment in place, shall be furnished and erected in place by the Contractor.

J. The Contractor shall install fixtures at mounting heights indicated on the Drawings or as instructed by the Engineer. In areas with exposed ducts and/or piping, installation of lighting fixtures shall be adapted to field conditions as determined by the Engineer.

K. The Contractor shall support each fixture securely. Each fluorescent fixture shall be secured to the building structure. The Contractor shall not secure fixtures to the work of other trades, unless specified or noted otherwise, and shall not support fixtures from plaster. The Contractor shall furnish and install all steel members and supports as required to fasten and suspend fixtures from the structure.

L. In all mechanical equipment areas, the Contractor shall install lighting fixtures on the ceiling after all piping and equipment therein has been installed. Exact locations for such fixtures may be determined by the Engineer on the site during the course of the work.

M. Upon completion of work, and after the building area is broom clean, all fixtures shall be made clean and free of dust and all other foreign matter both on visible surfaces, and on surfaces that affect the lighting performance of the fixture including diffusers, lenses, louvers, reflectors, and lamps.

N. All fixtures that require physical adjustment shall be so adjusted in accordance with the directions of the Engineer. The Contractor shall also adjust angular direction of fixtures and/or lamps, as directed.

O. Relamping access of fixtures including LED fixtures shall require no special tools. All optical control surfaces such as lenses and reflectors shall be safely and securely attached to fixtures and shall be easily and quickly removed and replaced for cleaning without the use of special tools. No fixture part that may be removed, for maintenance, shall be held in place by metal tabs that must be bent to remove said part.

P. The Contractor shall furnish and install time switches and photocells as specified herein or indicated on the Drawings. Time switches shall be provided with a manual bypass switch controlling the lights locally and remotely. Time switches shall control contactors, relays, or direct controlling of one, two, or three lighting circuits, as indicated. The Contractor shall furnish and install photocells as specified herein or indicated on the Drawings for automatic "ON/OFF" switching of outdoor lighting.

Q. Lighting contactors shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

R. One (1), ¾" diameter, 10'-0" long ground rod, furnish in accordance with Section 16170, shall be driven adjacent to each pole. The pole, anchor bolts, steel reinforcement bar in the base, and equipment grounding conductor shall all be bonded to the ground rod as indicated in the standard details.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Certified Shop Tests

a. The lighting fixtures shall be given routine factory tests in accordance with the requirement of ANSI, NEMA and Underwriters Laboratories standards.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

- END OF SECTION -

SECTION 16620

PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install a standby power engine generator set complete with base-mounted fuel storage tank, leak detection systems, exhaust silencer, batteries, charger, enclosure, and devices for automatic and manual control.

B. It is the intent under this Contract to require the generator manufacturer to provide a complete standby power system including, but not limited to, the following components:

a. Packaged Engine Generator System (16620)
b. Neutral Grounding Resistor (16391)
c. Medium Voltage Step-up Transformer (16322)
d. Medium Voltage Vacuum Circuit Breaker Switchgear – 27kV within a pre-fabricated electrical equipment building, complete with all required controls, HVAC, and electrical equipment (16345 + 16800)

C. It is the intent under this Contract to require an installation complete in every detail whether or not indicated on the Drawings or specified. Consequently, the Contractor is responsible for all details, devices, accessories and special construction necessary to properly install, adjust, test, and place in successful and continuous operation the engine-generator set.

D. It is also the intent under this Contract that the engine-generator set provided as part of this project shall be paralleled with the electrical utility. The Contractor will be responsible for providing all necessary controls, components, and interconnections between the generator and utility to accomplish successful parallel operation and closed-transitioning operations. **The contractor is responsible for obtaining (in writing) proof of operations from the Engineer and Owner, prior to the project receiving Substantial Completion.**

E. Use materials which are new, unused, and as specified, or, if not specifically indicated, the best and most suitable of their kinds for the purpose intended, and for the design and expected conditions of service, subject to the approval of the Engineer.

F. Provide workmanship that is first class in every respect. Employ workers thoroughly experienced in such work. A neat and workmanlike appearance in the finished work shall be required.

G. All materials used must bear the inspection labels of the Underwriter's Laboratories, if the material is of a class inspected by the Laboratory.

H. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

I. The engine generator sets shall fully comply with all current Environmental Protection Agency (EPA) emission regulations including, but not limited to, the New Source Performance Standards (NSPS) for stationary and non-road generator sets. The engine generator set(s) must meet the EPA new source performance requirements required at the time the engine generator set(s) submittal is approved by the engineer. Engines manufactured previous to the submittal approval date that do not meet the current regulated emissions levels are not acceptable.

J. Reference all Sections of Division 16.

1.02 CODES AND STANDARDS

A. The packaged engine-generator system shall comply with the following Codes and Standards as a minimum:

1. NEMA MG1, Motors and Generators.

2. NEMA MG2, Safety Standard for Construction and Guide for Selection, Installation and Use of Motors and Generators.

3. ISO STD 8528, Reciprocating Internal Combustion Engines.

4. ISO STD 3046, Performance Standard for Reciprocating Internal Combustion Engines.

5. NFPA 30, Flammable and Combustible Liquids Code.

6. NFPA 37, Standard for Installation and use of Stationary Combustible Engine and Gas Turbines.

7. NFPA 70, National Electrical Code

8. NFPA 70E, Standard for Electrical Safety in the Workplace

9. NFPA 110, Standard for Emergency and Standby Power Systems.

10. UL 508, Industrial Control Equipment.

11. EGSA, Electrical Generating Systems Association.

12. UL 2200 – Stationary Engine Generator Assemblies

13. ANSI C57, Dry-Type Transformers.

14. UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.

15. UL 1236 – Standard for Battery Chargers for Charging Engine Starter Batteries.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

3. Reports of Certified Shop and Field Tests

4. Operation and Maintenance Manuals

5. Manufacturer's Field Start-up Report

6. Manufacturer's Representative's Installation Certification

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for <u>each engine-generator set</u> shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter “C”, “D”, or “E” shall be typed or written in. The letter “C” shall be for full compliance with the requirement. The letter “D” shall be for a deviation from the requirement. The letter “E” shall be for taking exception to a requirement. Any requirements with the letter “D” or “E” beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this specification section.

2. Manufacturers printed specification sheets showing critical engine and generator set specifications including the following:

   - Dimensions, and weights
   - Guaranteed fuel consumption at 25%, 50%, 75% and 100% of full rated load
   - Engine bhp available
   - Brake Mean Effective Pressure (BMEP)
   - Engine jacket water heat rejection
   - Exhaust flow rate and temperature at 100% of rated load
   - Ventilation and combustion air requirements
   - Exhaust backpressure limitation
   - Liquid refill capacities
   - Voltage regulation characteristics
   - Guaranteed noise levels

3. Alternator technical electrical data, including, but not limited to:

   - Alternator efficiency at 50%, 75%, and 100% load
   - Telephone Interference Factor (TIF)
   - Harmonic waveform distortion
   - Type of winding insulation and generator temperature rise
   - Per unit subtransient impedance X'' and X/R ratios for positive, negative, and zero sequences
   - Transient reactance (Xd')
   - Synchronous reactance (Xd)
   - Sub transient time constant (Td'')
   - Transient time constant (Td)
   - DC time constant (Tdc)
   - Decrement curve

4. Manufacturer's printed warranty statement of the engine and generator set showing single source responsibility by the engine manufacturer.

5. Generator control panel equipment and features. Include a written explanation of the auto start/stop logic and operation.

6. Engine-generator set and accessory product data sheets including, but not limited to, the following:

   - Alternator strip heater
   - Radiator
   - Seismically rated vibration isolators

- Flexible exhaust coupling
- Exhaust silencer
- Batteries
- Battery charger
- Engine manufacturers shutdown contactors
- Jacket coolant heater
- Fuel cooler
- Fuel tank(s) and pump(s)
- Fuel level devices
- Output circuit breaker and trip unit
- Conduit
- Wire and Cable
- Wiring Devices
- Lighting
- Panelboards/combination power unit

7. Standard dealer preventative maintenance contract for review and possible adoption under a separate contract. Dealer must have existing contracts and personnel and contractual detailed performance information available.

8. Normal operating ranges for systems temperature, pressure and speed.

9. Manufacturer's part number for the engine and generator operation guide, parts book, service manual, warranty policy, and installation guide.

10. Location of other similar units showing compliance with the experience requirements specified herein.

11. Phone numbers of twenty-four (24) hour products support contacts and locations.

12. Drawing showing right hand, left hand, and top views of proposed assembly; battery rack, isolators, exhaust silencer, conduit stub up locations, and flexible fittings; wiring schematics, interconnection diagrams (point to point), and written description of engine generator controls and alarm circuits.

13. Control panel layout drawings and wiring diagrams.

14. Drawings and specifications for base-mounted fuel storage tank with accessories, day tank with accessories and leak detection system.

15. EPA Certificate of Conformity for Exhaust Emissions

16. Detailed drawings showing plan, front, and side views as well as appropriate section views of the weatherproof, engine-generator enclosure. Include product data sheets for all appurtenances (e.g. exhaust fan, thermostat, lighting, switches, receptacles, combination power unit, etc.) to be furnished and installed in the enclosure. Drawings shall be of sufficient detail to assure proper installation by the Contractor.

17. Detailed drawings of the portable trailer including product data sheets.

18. Detailed drawings of the radiator mounted load bank including top, front, and side views. Include product data sheets for all components, power wiring diagrams, control panel layout drawings, and control panel wiring diagrams. Submit instruction manuals that include installation, operation, and maintenance instructions and a spare parts list.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 REPORTS OF CERTIFIED SHOP AND FIELD TESTS

A. Submit two (2) certified copies of all test reports. This includes all shop tests and field tests. Certified shop test reports for prototype engine-generator sets are unacceptable. The manufacturer's serial number for the actual engine-generator set furnished for this project shall appear on all test reports.

1.06 OPERATION AND MAINTENANCE MANUALS

A. Two (2) preliminary copies of Operation and Maintenance Manuals, prepared specifically for this Project, shall be furnished for each item of equipment furnished under this Contract. The preliminary manuals shall be provided to the Engineer not more than 10 days after the equipment arrives on the project site.

B. The preliminary manuals shall be reviewed by the Engineer prior to the Contractor submitting final copies for distribution to the Owner. Following review of the preliminary copies of the Operation and Maintenance Manuals, one (1) copy will be returned to the Contractor with required revisions noted, or the acceptance of the Engineer noted.

C. Manuals shall contain complete information in connection with assembly, operation, lubrication, adjustment, wiring diagrams and schematics, maintenance, and repair, including detailed parts lists with drawings or photographs identifying the parts. Manuals shall contain all information submitted as part of the shop drawing review process.

D. Manuals furnished shall be assembled and bound in separate volumes, by major equipment items or trades, and properly indexed to facilitate locating any required information. In addition, manuals should be labeled in the front cover with the project, name, equipment description, and manufacturer contract information.

E. Engineer and the Owner shall be the sole judge of the acceptability and completeness of the manuals and may reject any submittal for insufficient information included, incorrect references and/or the manner in which the material is assembled.

F. Following the Engineer's review of the preliminary manuals, the Contractor shall submit five (5) paper copies and two (2) electronic copies of the final Operation and Maintenance Manuals to the Owner. The manuals shall reflect the required revisions noted during the Engineer's review of the preliminary documents, as well as any changes made during installation. Failure of the final manuals to reflect the required revisions noted by the Engineer as well as changes made during installation will result in the manuals being returned to the Contractor. Acceptable final Operation and Maintenance Manuals shall be provided not more than one (1) month after receipt of the Engineer's comments.

1.08 IDENTIFICATION

A. Each engine-generator set shall be identified with the identification name/number indicated on the Drawings (e.g., Generator No. 2). A nameplate shall be securely affixed in a conspicuous place on the generator main circuit breaker or output termination box enclosure. Nameplates shall be as specified in Section 16195, Electrical - Identification.

1.09 WARRANTY TERMS

A. The manufacturer's and Dealer's warranty shall in no event be for a period of less than five (5) years from date of issuance of Permit to Operate, and shall include travel time, repair labor, travel expense necessary for repairs at the jobsite, and expendables (lubricating oil, filters, coolant, and other service items made unusable by the defect) used during the course of repair. Running hours shall not be the limiting factor for the system warranty by either the manufacturer or servicing packaged engine-generator set dealer. Submittals received without written warranties as specified shall be rejected in their entirety. If the Permit to Operate for the system is not issued within twelve (12) months of the startup inspection, another startup inspection must be conducted and be found satisfactory for BCWS to accept and assume O&M responsibilities.

B. Provided warranty shall cover all equipment included in the scope of supply. This warranty shall include, but is not limited to, the following:

- New engine-generator set and respective auxiliary equipment
- All controls for the engine-generator set
- Complete diesel fuel system
- New neutral grounding resistor
- New medium voltage liquid filled pad-mounted, step-up transformer
- New 27kV switchgear and associated switchgear and generator controls

C. Batteries shall be provided with five (5) year full replacement guarantee, and a pro-rated replacement schedule thereafter.

1.10 OIL SAMPLING KIT

A. The generator set supplier shall provide an oil sampling analysis kit which operating personnel shall utilize for scheduled oil sampling. All equipment needed to take oil samples shall be provided in a kit and shall include the following:

1	Sample extraction gun
10	Bottles
10	Postage-paid mailers
1	Written instructions

An additional oil sampling kit shall be made available to the Owner to continue the sampling when the above specified kit has been depleted. All kits in addition to that specified above shall be at an additional cost to the Owner, if the Owner desires to continue the sampling service.

1.11 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The engine-generator set manufacturer shall be Caterpillar. The engine-generator set manufacturer and/or dealer shall be responsible for the entire engine-generator package including the engine-generator set with all accessories and equipment specified herein and all other devices required for a complete and operable system.

2.02 GENERAL DESCRIPTION

A. The engine-generator set shall be rated as specified herein and as indicated on the Drawings. It shall have the capability to operate at its standby rating for the duration of any power outage with all accessories including engine running devices, silencer, radiator, cooling fans, fuel system, and all appurtenances complete as it would be installed in the field. The Contractor shall note and take appropriate action regarding the intended operation of the engine-generator sets while connected to motor driven loads controlled by variable frequency drives (VFDs).

2.03 ENGINE

A. The engine shall be diesel, 4 cycle, radiator cooled, and shall be turbocharged having an operating speed of 1800 RPM. Engine shall operate on ASTM D-975 Grade No. 2D S15 ultra-low sulfur diesel fuel.. Engines requiring any other fuel type are not acceptable.

B. The engine will not be acceptable if the design is a conversion of a naturally aspirated engine to which a turbo-blower has been attached, unless the engine is certified by the manufacturer as having been analyzed and redesigned with ample provisions for increased stresses and bearing or heat loads due to increased pressures and rate of heat liberation.

C. Break mean effective pressure (BMEP) shall not exceed 380 psi at rated load. Brake Horsepower (BHP), and Engine-Generator efficiency shall conform with ASME, IEEE and NEMA standards that electrical energy delivered by the machine is within the minimum certified guaranteed fuel oil consumption rate and evidence that these parameters have been met shall be furnished.

D. Only engine manufacturers' standard ratings shall be acceptable. No dealer special ratings will be acceptable.

E. The specified standby kW rating shall be for continuous electrical service during interruption of the normal utility source, per NEMA standards.

F. Engine speeds shall be governed by an electronic isochronous governor that will sense generator speed and provide accurate load transient correction capability at less than 0.5 percent regulation, from no load to full load generator output.

2.04 ALTERNATOR

A. The alternator shall conform with NEMA and IEEE standards and be rated as indicated on the Drawings. The alternator shall have a UL 2200 listing. The alternator shall be brushless, salient pole, 2/3 pole pitch and synchronous for operation at 4160VAC, wye connected, as indicated on the Drawings. The generator shall be capable of delivering 3,700 SkVA (minimum) at an instantaneous voltage dip of no more than 20% voltage drop.

B. Laminations and windings shall be designed for minimum reactance, low voltage waveform distortion and maximum efficiency.

C. The main stator coils shall be form wound. Insulation shall be Class H, 105 degrees C rise according to NEMA standards. The insulation system shall be made of epoxies and polyesters which are inorganic compounds and shall prevent fungus growth.

D. The rotor shall be dynamically balanced and include amortisseur windings to minimize voltage deviations and heating effects under unbalanced load conditions.

E. Radio interference suppression (both directions) shall be provided in accordance with NEMA and IEEE Standards.

F. The alternator shall have a brushless, permanent magnet generator (PMG) excitation support system to provide input to the automatic voltage regulator to enable the alternator to support 300% of rated current for 10 seconds to allow fault clearing.

G. Waveform deviation shall not exceed 5% from true sine wave. The transient response from no load to full load in one step of the engine-generator set shall not exceed a voltage dip of 35%, a frequency dip of 20%, and shall recover to complete steady state performance within 12 seconds for both voltage and frequency. The transient response from full load to no load in one step shall not exceed a voltage overshoot of 7% and shall recover to steady state performance within 3 seconds. Transient performance shall be in accordance with ISO 8528.

H. The Telephone Influence Factor (TIF) shall be less than 50.

I. The voltage regulator shall be an adjustable, solid-state, three-phase RMS sensing, volts/hertz type. Voltage regulation shall be a minimum of +/-0.25% from no load to continuous rating. The voltage regulator shall provide +/-10% voltage adjustment. The voltage regulator shall be located within the engine control panel.

J. An alternator mounted strip heater shall be furnished and installed as part of the system. The strip heater shall be energized to prevent condensation when the engine generator set is not running.

2.05 GENERATOR 5kV LOAD INTERRUPTING SWITCH

A. General

1. The generator alternator shall be connected to a deadfront, completely metal enclosed vertical section containing a load interrupter switch and fuses of the number, rating and type noted on the Drawings or specified herein.

2. The load interrupter switch section shall bear a U.L. label.

3. The primary incoming line section shall be designed for operation on a 4.16kV, three-phase, 3 wire, solidly grounded, 60 hertz system.

4. The load interrupter switch shall be rated and designed to comply with the performance requirements of ANSI C37.32. Switch shall be manually operated, three-pole, single throw disconnecting type with an integral interrupter and stored energy spring. The operating handle shall be externally operated.

B. Ratings

1. The load interrupter switch shall have the following ratings:

Maximum Design Voltage	4.76 kV
Basic Impulse Level	60 kV
Continuous and Load Interrupting Current	600 Amperes
Momentary Current (Switch Closed, 10 Cycle)	61 kA Asym.
Fault Close Current	61 kA Asym.
Two-Second Current	38 kA Sym.

C. Stationary Structure

1. The following features shall be supplied on each three-pole, two-position, open-closed load interrupter switch:

   a. A high impact viewing window that permits full view of the position of all three switch blades through the closed door.

   b. The door shall be interlocked with the switch so that:

      1. The switch must be opened before the door can be opened.

      2. The door must be closed before the switch can be closed.

   c. A grounded metal barrier in front of every switch to prevent inadvertent contact with any live part yet allow for a full-view inspection on the switch blade position.

   d. Provision for padlocking the switch in the open or closed position.

   e. Permanent "Open-Closed" switch position indicators.

2. Vertical section construction shall be of the universal frame type using die-formed and bolted parts. All enclosing covers and doors shall be fabricated from not less than 11-gauge steel. Top cover shall be removable. Rear doors shall be hinged with tamper resistant padlockable latches.

3. Each load interrupter switch shall have a single, full length, flanged front door and shall be equipped with two rotary latched type padlockable handles. Provisions shall be made for operating the switch and storing the removable handle without opening the full length door.

4. A vertical barrier shall be provided between the switch and cable area.

5. A lower screen barrier shall be provided between front door and fuses.

6. Each load interrupter switch shall be quick-make, quick-break, three pole, gang operated, with stored energy operation.

7. A manual over toggle type mechanism shall be supplied which utilizes a heavy duty coil spring to provide opening and closing action of the switch. The speed of the opening and closing switch shall be independent of the operator and it shall be impossible to tease the switch into any intermediate position under normal operation.

8. Each interrupter switch shall have separate main and make/break contacts to provide maximum endurance for fault close and load interrupting duty.

9. The switch assembly shall have insulating barriers between phases and between outer phases and the enclosure.

10. A maintenance provision shall be provided for slow closing the switch to check switch blade engagement and slow opening the switch to check operation of the arc interrupting contacts.

11. Three (3) 5kV distribution class surge arresters shall be provided connected at the incoming terminations and securely grounded to the ground bus.

12. Primary incoming line section shall be furnished complete with thermostatically controlled space heaters. Utilize tubular type operated at half voltage for long life; 250 volt rated heaters operating at 120 volt. Space heaters in primary section shall be wired to the space heater circuits in the respective secondary section.

D. Bus

1. Buses and main connections shall consist of flat tin-plated copper bars.

2. Buses shall be fully insulated for its entire length with a flame retardant and track-resistant epoxy coating installed by the fluidized bed process. Provide the 3 phase bus of each unit with insulation to completely encase each bar except provide removable, insulating boots at bus joints.

3. The bus shall be braced to withstand fault currents equal to the fault close (momentary) rating of the switches.

4. A ground bus of adequate capacity shall be furnished and installed with a connector for the incoming grounding conductor. The ground bus shall be of sufficient size to conduct the rated two-second current of the load interrupter switch.

E. Terminations

1. One terminal pad per phase shall be provided for attaching Contractor supplied cable terminal lugs for a maximum of two conductors per phase of the sizes required.

2. Incoming line terminals shall be irreversible compression type and shall be suitable for terminating shielded cables of at least the size indicated on the Drawings with Class 1 terminations. The incoming lines shall enter from the top of the enclosure. Adequate space shall be provided for the terminations on the incoming lines.

F. Fuses

1. Fault protection shall be furnished by fuses as specified herein, and indicated on the Drawings. The fuses shall be current limiting type.

2. Provide spare power fuses as specified herein and provide a storage rack on the inside of the main door for these spare fuses.

3. Each fusible switch section shall be furnished with a blown fuse low voltage contact for remote blown fuse indication.

G. Control Wiring and Testing

1. Small wiring, fuse blocks, and terminal blocks within the vertical section shall be furnished as required.

2. Wire and factory test each load interrupter switch to satisfy the requirements of the operation described or necessary.

3. Small wiring shall be NEC Type SIS, single-conductor, stranded copper, rated 600 volts, 90°C bundled and secured with nylon ties. Provide flexible stranding for swinging doors and panels. Minimum wire size shall be No. 14 AWG for voltage transformer and control circuits. For current transformer circuits, minimum wire size shall be No. 12 AWG. Number 10 AWG or larger shall be used to decrease resistance as required.

4. Route outgoing control wires for outgoing or intraconnecting wiring to the master terminal blocks with suitable numbering strips numbered in agreement with the manufacturer's detailed wiring diagrams.

5. Terminate control wiring in molded terminal blocks acceptable to Engineer. Provide a minimum of 10 percent (10%) spare terminal blocks for each switch.

6. Number wiring with shrink-type tag devices at both ends consistent with the manufacturer's detailed wiring diagrams. Duplication of wire numbers and terminal block numbers is not acceptable.

H. Nameplates

1. Provide engraved plastic nameplates to identify equipment sections, door mounted devices, and internal components.

2. Nameplates shall be as specified in Section 16195, Electrical – Identification.

3. Provide a master nameplate giving equipment designation, voltage rating, current rating, short circuit rating, manufacturer's name, general/work order number and item number.

4. Auxiliary components mounted within the assembly, such as fuse blocks, relays, control power transformers, and other devices, shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

I. Warning Signs

1. Warning signs shall be provided as specified in Section 16195, Electrical Identification.

K. Finish

1. The load interrupter switch finish shall consist of gray (ANSI-61), thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray. Prior to shipment, the complete assemblies, indoor as well as outdoor, shall be given 1.5 to 2.0 mil thick exterior finish spray coat of air drying high-gloss gray enamel.

2.06 CONTROLS

A. Engine-generator monitoring and controls shall be mounted in a single NEMA 1 (gasketed) dust-tight enclosure. A suitable accessible terminal strip having all wires properly identified shall be furnished within the enclosure. The control panel shall be mounted at a height of 4'-8" measured from the center of the panel to the equipment pad or enclosure floor.

B. The control panel shall accept a dry contact input for engine starting from remote locations. The starting and stopping of the engine-generator set shall be initiated through the control panel only. When the engine starts, starting control shall automatically disconnect cranking controls. Four (4) cranking cycles of 10 seconds "ON", 10 seconds "OFF" shall be provided. The starting controls shall prevent re-cranking for a definite time after source voltage has been reduced to a low value, or the four (4) cranking cycles have been reached without a successful start. The automatic engine starting controls shall use industrial rated control type elements throughout, and controls shall have the capability to operate at 50% battery voltage.

C. Speed sensing shall be provided to protect against accidental starter engagement with a moving flywheel. Battery charging alternation output voltage is not acceptable for this purpose.

D. A generator/exciter field circuit breaker with shunt trip device shall be furnished and installed as part of the engine generator set. Shunt trip shall be activated upon engine-generator fault conditions.

E. A main line, 5kV class, load interrupter switch as specified herein and sized as indicated on the Drawings, shall be installed as a load circuit interrupting and protection device in a NEMA 1 (gasketed) dust-tight enclosure.

F. Engine-generator monitoring and control shall be provided using a microprocessor based control panel complete with an LCD display. The devices necessary for automatic starting shall be on the engine and in the engine control panel. Control panel shall have integral paralleling and load sharing controls. The control shall be equivalent to an EMCP 4.3 or better. The following hardware (minimum) shall be provided on the front of the control panel; the use of the LCD display and keypad to accomplish the same function is not acceptable:

1. Keyed engine control mode switch (Run-Off-Auto)

2. Large, red emergency stop pushbutton

3. Generator voltage adjust potentiometer

4. Generator frequency adjust potentiometer

G. The following parameters (minimum) shall be shown on the LCD display or otherwise be indicated at the control panel:

1. Engine oil pressure

2. Coolant temperature

3. Generator output voltage

4. Generator output current

5. Generator elapsed run time

6. Generator output frequency

7. Engine run

8. Engine fail

9. Low coolant temperature

10. Pre-high engine temperature

11. Pre-low fuel level

12. Engine speed (RPM)

H. The following events (minimum) shall cause an immediate shutdown of the engine-generator set if it is operating, or prevent starting if it is not operating. The specific event that causes the shutdown/prevents starting shall be shown on the LCD display or otherwise be indicated at the control panel. A reset shall be required to clear the fault and allow the unit to operate:

1. Engine coolant high temperature

2. Engine low oil pressure

3. Low fuel level

4. Engine overspeed

5. Engine overcrank

6. Engine tried to start but failed

7. Low coolant level

I. The generator control panel shall have a communication port capable of transmitting all available engine-generator set data via Modbus TCP protocol. The generator control panel shall be provided with media converters to transition to fiber for communication of data external of the generator enclosure (e.g. to PLC-13 associated with the 27kV Switchgear).

J. The generator control panel shall have Form C dry contacts rated 5A (minimum) at 120VAC/24VDC for the following signals:

1. Engine coolant high temperature

2. Engine low oil pressure

3. Pre-low fuel level

4. Low fuel level

5. Engine overspeed

6. Engine overcrank

7. Engine tried to start but failed

8. Low coolant level

9. Engine fail

10. Engine run

The normally closed (NC) contacts for all of the above signals (except engine run and Pre-low fuel level) shall be wired in series to provide a common "Generator System Failure" alarm for remote indication. Other contacts shall also be wired as a part of this alarm as specified elsewhere herein.

2.07 ENGINE ACCESSORIES

A. Furnish and install the engine with all accessory equipment and appurtenances which are required for proper operation, including the following:

1. Heavy duty dry type air filler with restriction indicator

2. Heavy duty lubricating oil filter, bypass type, with replaceable absorbent-type elements

3. Lubricating oil cooler, water cooled

4. Heavy duty fuel oil filter, spin-on, with non-replaceable absorbent-type elements

5. Fuel oil fuel/water separator

6. Heavy duty crankcase vapor coalescer

7. Radiator mounted fuel cooler to cool recirculated fuel before it is re-deposited into the fuel tank as recommended by the manufacturer.

2.08 MOUNTING

A. Couple the engine and generator together through a flexible, non-backlash type, all metal coupling which overcomes all normal misalignment stresses and transmits full engine torque with ample safety factor. Also provide flexible connections for piping connections.

2.09 COOLING SYSTEM

A. Provide a radiator manufactured of a non-corrosive material mounted on the engine. The radiator core shall be coated with a corrosion resistant coating. Corrosion resistant coating shall be a corrosion resistant baked phenolic coating or similar.

B. Connect the radiator to the engine internal cooling system with flexible piping. Furnish appropriately sized coolant expansion tank for the cooling system.

C. The engine shall be cooled through a radiator sized to continuously maintain safe operation at full load and at 105°F outside ambient air with 50% ethylene glycol coolant. A blower type fan and low noise fan drive and controls shall be furnished. The fan and all rotating members and drive belts shall be guarded and meet OSHA standards. Proof of 105°F ambient temperature capability shall be required.

D. Coolant

1. After the cooling system is flushed and cleaned, provide an initial fill of coolant consisting of 50% ethylene glycol. An anti-corrosion treatment shall be added during the initial fill.

2. The coolant shall meet the requirements of the generator manufacturer including corrosion inhibitors provided in the coolant to protect the engine cooling system.

E. The engine shall be equipped with coolant heaters. Heaters shall be in accordance with the following:

1. Unit mounted thermal circulation type coolant heater with coolant recirculation pump shall be furnished to maintain engine jacket coolant temperature as recommended by manufacturer in a 3 phase, ambient temperature of minus 20°F. The heater shall be 480 VAC, 60 hertz, 3-phase, thermostatically controlled.

2. The heater shall be of sufficient capacity to keep the coolant at a suitable temperature for trouble-free starting.

3. Each heater shall be provided with a suitable contactor to automatically disconnect the heater when the engine is started.

2.10 ENGINE STARTING AND CHARGING SYSTEM

A. Engine starting batteries shall be sealed, lead-acid type, rated 12 volts, wired for 24V starting batteries shall have adequate capacity for rolling the engine for five (5), ten (10) second cycles without starting, and then operating the control devices in the local generator controls as well as the generator paralleling controls for two (2) hours. The batteries shall be mounted on a suitable non-corrosive rack. Batteries shall have battery cables with lugs and shall be provided with lugs for connection to the battery charger.

B. Battery charger shall be a U.L. 1236 listed, automatic, solid-state battery charger, 20 A (min.) current limited, ±2% voltage regulation, ±10% line voltage variation, automatic float equalizing system, DC voltmeter, and DC ammeter. Provide a Form C unpowered (dry) contact to indicate a low battery alarm condition.

C. In addition, the engine shall be provided with an engine battery charging alternator that automatically changes the starting batteries during engine operation.

2.11 EXHAUST SILENCER

A. Furnish and install an exhaust silencer. Silencers shall be of critical type and sized to produce a high degree of silencing. Reference the sound attenuation requirements specified herein.

B. Connect the silencer to the engine exhaust manifold with a high corrosion and temperature resistant stainless steel flexible convoluted exhaust pipe. Use flange-type connections. Provide a taper-cut tail pipe complete with rain cap to exhaust the gases to the atmosphere.

C. The silencer (if installed inside), exhaust piping, and expansion fittings, including collector box, shall be completely covered with a removable insulation blanket in order to protect operating personnel and to reduce noise. Insulation shall be of composite fiberglass and stainless steel construction capable of withstanding 1200°F continuously. The insulation blankets shall be tailored and custom fabricated to fit the contours of the manifolds. Average

weight of the insulating blanket shall be 1.5 psf. Insulation shall conform to MIL-1-16411D, Type II and shall be custom fabricated to fit the contours of the components.

D. The silencer system shall be designed, furnished, and installed to prevent moisture and condensation from corroding the silencer. All exterior components of the exhaust system shall be of 316 stainless steel.

E. Silencer shall be mounted within or exterior to the generator enclosure dependent on generator size and manufacturers standards. Silencers mounted on the outside of the enclosure shall be 316 stainless steel construction on its interior and exterior. Silencers mounted within the generator enclosure shall be painted steel and insulated using a calcium silicate material covered by a brushed aluminum skin.

2.12 WIRING

A. Furnish and install internal wiring in the engine-generator set. All internal wiring between the generator and engine-generator control panel, the on-board power source and all accessories shall be provided.

2.13 BASE MOUNTED FUEL TANK

A. The generator set shall be supplied with a U.L.-142 listed base mounted fuel tank of sufficient capacity to operate the engine-generator set at full load for a minimum of 24 hours. The tank, painted in a color as selected by the Owner, shall be fabricated from steel with a rupture basin and leak detector system. The alarm and indicator for the leak detection shall be mounted adjacent to the generator control panel and a contact for remote indication of a fuel leak condition shall be provided. This contact shall be wired as part of a common "Generator System Failure" alarm.

B. A level device shall also be furnished and installed to provide a local (generator control panel) and remote indication of pre-low fuel tank level and low fuel tank level. The pre-low fuel tank level shall activate a set of dry contacts for remote alarm indication. The low fuel tank level alarm shall shut down the engine to prevent the fuel level from dropping below the fuel pickup piping in the fuel tank. The pre-low fuel level alarm shall activate when only 6 hours of fuel for full load operation remains in the fuel tank. The remote low fuel tank level alarm shall be wired separate from the "Generator System Failure" alarm.

C. The tank shall be supplied with all necessary fuel supply, return, vent, and fill fittings and a fuel level gauge. The lockable fill port and level gauge shall be easily accessible from outside the enclosure. Provide a valve that automatically closes the fuel fill inlet when the tank level reaches 95% of its capacity. The vent line shall be piped to the outside and be equipped with a fill whistle.

D. The tank shall also be provided with supply/return ports on the opposite side of the tank for future connection to a portable fuel polishing system.

D. The underside of the tank shall not be in contact with the mounting surface (concrete pad).

E. The tank shall be equipped with an immersion heater to keep the fuel at the inlet to the engine within an acceptable temperature range. The heater shall be wired for operation on a 480 VAC, single-phase, 60 hertz power source.

2.14 WEATHERPROOF ENGINE - GENERATOR ENCLOSURE

A. Furnish and install an outdoor, weather-protective housing. The housing shall be furnished complete with a full sub-base floor resulting in complete enclosure. The enclosure shall be factory-assembled to the engine-generator set base and radiator cowling. Lifting eyes shall be provided. Housing shall provide ample airflow for generator set operation. The housing shall be constructed of 12 gauge (minimum) aluminum or 14 gauge (minimum) galvanized steel, reinforced to be vibration free in the operating mode. The housing shall have hinged side-access doors and rear control panel access door. Each door shall have at least two latch-bearing points. All doors shall be lockable. All steel sheet metal shall be primed for corrosion protection and finish painted in a color as selected by the Owner. Roof shall be peaked to allow drainage of rain water. Unit shall have sufficient guards to prevent entrance by small animals. Batteries shall fit inside enclosure and alongside the engine (batteries under the generator are not acceptable). Unit shall have engine coolant and oil drains piped to outside the unit to facilitate maintenance. Each drain line shall have a valve located near the fluid source.

B. Provide walk-around access within the enclosure. Access shall be two feet (minimum) measured from the outermost engine generator component or four feet from the rails, whichever is greater. Interior height from the sub-base floor to the ceiling shall be 84" minimum. Doors shall have panic hardware and height shall be 72", minimum. "Skin-tight", "reach in", or "Drop-over" housings are not acceptable.

C. Enclosure shall be sound attenuated to provide sound level as specified herein.

D. The enclosure shall be furnished with a power panel, dry type transformer, and lighting panel as specified in Sections 16470 and 16461. These units shall serve as the power distribution panels for all accessories specified herein and indicated on the Drawings (e.g. alternator mounted space heater, battery charger, leak detection system, etc.) that require "shore power". The enclosure manufacturer shall furnish and install conduit and wire necessary to provide the power from the unit to all accessories.

E. All hardware (nuts, bolts, screws, washers, etc.) that is installed on the exterior of the generator enclosure shall be stainless steel. Galvanized steel hardware is not acceptable.

F. Aluminum stairs and aluminum handrail shall be furnished at each door. The aluminum stairs shall be as specified in Specification Section 05510 – Metal Stairs. The aluminum handrail shall be as specified in Section 05520 – Handrails and Railings. The Contractor shall extend the generator concrete pad as necessary to accommodate the installation of the aluminum stairs.

G. Linear fluorescent or LED lighting shall be provided in sufficient quantity to maintain 20 foot-candles of illumination at floor level and shall be suitable for operation in cold weather. Compact fluorescent lighting fixtures are not acceptable. Interior lighting shall be controlled by 3-way light switches located at each door. Reference Section 16141.

H. Convenience receptacles shall be furnished at each door within the enclosure. Receptacles shall be 125V, 20A, two-pole, three wire grounded type. Reference Section 16141.

I. Conduit and wire shall be in accordance with Sections 16111 and 16123, respectively.

J. All air intake louvers shall be furnished with rain guards or designed to eliminate water intrusion to the interior of the enclosure when the generator is operating at full load (maximum airflow) during rain events.

2.15 SOUND ATTENUATION

A. Extreme care shall be exercised in providing equipment for and setting the engine-generator in place to guard against excessive noise transmission and vibrations. Fasten to the underside of the skids seismically-rated spring type isolators.

B. The engine-generator enclosure shall be designed, furnished, and installed to reduce source noise to 78 dB(A) as measured at seven (7) meters from the enclosure.

2.16 NEUTRAL GROUNDING RESISTOR

A. Furnish and install a neutral grounding resistor within the generator enclosure as specified in Specification Section 16391 – Neutral Grounding Resistors.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The standby generator system shall be furnished and installed as indicated on the Drawings and as recommended by the equipment manufacturer.

B. The initial filling of the fuel storage tank shall be provided by the Contractor. Fuel tank shall be filled to its full capacity. At the conclusion of all field testing, the Contractor shall fill the fuel storage tank back to its full capacity. Fuel shall be ultra-low sulfur diesel Grade No. 2D S15 in accordance with ASTM D-975. Fuel shall be new and free from contaminants and water.

3.02 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified generator manufacturer's factory-trained technical representative who shall adequately supervise the installation and of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

B. The manufacturer’s technical representative shall perform all startup and field testing of the generator assembly as specified herein.

C. The Contractor shall provide training for the Owner’s personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner’s personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the generator has been installed and tested. Training shall be conducted at times coordinated with the Owner.

D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of two (2) working days during installation of the engine-generator set.

2. One (1) trip of one (1) working day to perform startup of the engine-generator set.

3. One (1) trip of two (2) working days to perform the field testing of the engine-generator set.

4. One (1) trip of one (1) working day to perform training as specified herein.

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

a. None required.

2. Certified Shop Tests

a. Fully test the engine-generator set with all accessories in the manufacturer's plant before shipment. Tests shall be conducted through the use of balanced, three-phase, dry-type, resistive load banks.

b. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure.

c. The manufacturer shall conduct a shop test run of at least six (6) consecutive hours for the set under the following conditions of load, in the following order:

3 hours - full load
1 hour - 3/4 load
1 hour - 1/2 load
1 hour - 1/4 load

d. Fuel, lubricants, and other fluids as required for the shop tests shall be furnished by the manufacturer.

2. Field Tests

a. Field tests shall be performed by the generator manufacturer’s technical representative. The Contractor shall obtain from the manufacturer and submit a detailed field test plan and procedures documenting the intended field test program.

b. In the presence of the Engineer and Owner, the representative shall inspect, adjust, and test the entire system after installation and leave in good working order. Field tests specific to each generator shall be conducted after the entire engine-generator system is installed including, but not limited to, the following: diesel fuel tanks including leak detection, exhaust silencer, radiators, enclosures, batteries, and all other equipment included in the complete system.

c. Field test the generator enclosure to ensure the enclosure performs as specified herein. The generator enclosure field tests shall include water tests to confirm the enclosure does not leak and that the air intake louvers eliminate water intrusion to the interior of the generator enclosure when the generator is operating at its full load capacity (maximum airflow). A garden hose shall be used to simulate falling rain for this test. Water supply and garden hose will be provided by the Owner for this test.

d. Field test, as far as practicable, all control, shutdown, and alarm circuits. Document the successful completion of these tests as witnessed by the Owner and the Engineer.

e. Generator load tests shall be conducted through the use of balanced, three-phase, dry-type, reactive (0.8 power factor) load banks. Conduct a continuous run test using the load bank without shutdown for the engine-generator set under the following load conditions (in this specific order) and in the presence of the Owner and Engineer:

- 5 hours, full load
- 1 hour, 3/4 load
- 1 hour, 1/2 load
- 1 hour, 1/4 load

Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure every 15 minutes during the continuous run test. If any failures, malfunctions, and/or shutdowns occur during this test, the problems shall be fixed and the test shall be restarted. The test shall not be considered complete until the generator has operated for eight (8) consecutive hours without any shutdowns under the conditions listed above.

f. After successful completion of the load bank tests, the generator system shall then be operated for a minimum of four (4) hours with plant loads during a time period when the plant is operating at average demand. The same data shall be recorded at 15 minute intervals for this load test as for the load bank test.

g. Demonstrate the system will transfer properly with only one (1) of the two (2) generators operating.

h. The Contractor shall collect a sample of engine oil from each engine for

analysis after the start-up and testing has been completed. The sampling method shall be of the atomic absorption spectrophotometry method and be accurate to within a fraction of one part per million for the following elements:

- Iron
- Chromium
- Copper
- Aluminum
- Silicon
- Lead

The sample shall also be tested for the presence of water, fuel dilution, and coolant.

The oil samples shall be analyzed at an independent laboratory that is not a part of the engine supplier's facility. Immediate notification of critical results shall be provided to the Owner when the analysis shows any critical reading.

i. All fuel, lubricants, and other fluids required to complete all field tests shall be paid for by the Contractor.

3.04 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

- END OF SECTION -

SECTION 16670

LIGHTNING PROTECTION SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation a complete lightning protection system as specified herein. This is a performance specification. The Drawings do not show a complete lightning protection system design. The Contractor shall retain the services of a firm specializing in the design, installation, and testing of lightning protection systems.

B. Lightning Protection Systems shall be installed on the following buildings and enclosures:

1. Blower Electrical Power Center

2. Main Electrical Power Center (27kV)

3. Generator Enclosure

1.02 CODES AND STANDARDS

A. The system shall comply with the following codes and standards:

1. Underwriters Laboratories, Inc. (U.L.):

a. U.L. 96 - Lightning System Components

b. U.L. 96A - Installation Requirements for Lightning Protection Systems

c. U.L. 467 – Grounding and Bonding Equipment

2. National Fire Protection Association (NFPA):

a. ANSI/NFPA 780 - Lightning Protection Code

3. Lightning Protection Institute (LPI):

a. LPI-175 - Standard of Practice

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Spare Parts List

4. Test Reports

5. UL Master Label Certification

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for each lightning protection system shall include, but not be limited to:

1. Product data sheets.

2. Complete U.L. approved, full size layout and installation drawings/details with clearly marked dimensions. Drawings shall indicate the exact location of all system components. Drawings shall be signed by a full-time employee of the lightning protection system manufacturer who is in responsible charge of this project and has been engaged in the business for at least ten (10) years.

3. Weights of major all components.

4. Bill of material list for each lightning protection system.

5. Manufacturer's installation instructions.

6. Manufacturer's and installer's standard warranty.

7. Evidence of the designer/installers UL listing.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books and/or leaflets.

2. Recommended spare parts list.

3. Final as-built construction drawings included in the shop drawings incorporating all changes made during the installation.

4. All other information that was included in the shop drawing submittal.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The lightning protection systems covered by this Specification shall be furnished using standard components of proven performance as manufactured by reputable concerns. The systems shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed.

B. The lightning protection systems shall be furnished and installed by A-C Lightning Security, Inc., Thompson Lightning Protection, Inc, Lightning Elimination and Consultants, Modern Lightning Protection Company, Inc. or approved equal.

C. System designer/supplier qualifications shall be as follows:

1. System components shall be manufactured by a company specializing in lightning protection equipment with a minimum of 5 years documented experience. Company shall be listed in the Section entitled "Lightning Conductor, Air Terminals and Fittings" of the U.L. "Electrical Construction Materials Directory" for at least 5 years previous to this Contract's bid opening date.

2. The system designer/installer shall be an authorized installer of manufacturer with a minimum of 5 years of documented experience. Designer/Installer shall be listed in the section entitled "Lightning Protection Installation" of the U.L. "Electrical Construction Materials Directory" for at least 5 years previous to this Contract's bid opening date.

2.02 LIGHTNING PROTECTION SYSTEMS

A. General

1. All components and parts of the lightning protection system shall be as specified herein. The materials used shall meet or exceed the material specification requirements of the Underwriters Laboratories, Inc. All materials shall be marked with a UL label or stamp.

2. The complete lightning protection system for both new structures and existing structures modified under this Contract shall be inspected and included in the Master Label certification.

B. Conductors

1. Conductors shall be aluminum cable, consisting of a minimum of 24 strands of No. 14 AWG aluminum wire. Copper conductors shall be furnished and installed only where required and when in contact with the earth. Where termination of copper conductors is required to aluminum parts, suitable bi-metallic connectors approved for the purpose shall be furnished and installed.

C. Fittings

1. Fittings shall be the bolted type with stainless steel bolts, nuts, and washers. Fittings shall be of cast metal construction specifically designed for the application. Crimp-type fittings are not acceptable. Bi-metallic type fittings shall be furnished where required.

D. Fasteners

1. Fasteners shall be manufactured from non-corrosive material of ample strength and rigidity for the application.

E. Bases

1. Bases shall be bolted style provided with the model to suit the application (i.e. parapet, standing seam, etc.). Bolts, nuts, and washers shall be made of stainless steel. Bases shall be of aluminum or bronze construction, compatible with the material of the surface to which it is attached. Crimp-type bases are not acceptable.

F. Ground Rods

1. Ground rods shall be 3/4-inch by 10-foot 0-inch sectional type copper-clad steel rods; as specified in Section 16170, Grounding and Bonding; quantity as required. Ground rods and all associated hardware shall be UL 467 listed.

G. Air Terminals

1. Air terminals shall be solid aluminum. Air terminals shall be tapered or blunt tip type to suit the application and furnished with air terminal bases and safety tips (ball or bullet type) for impalement protection.

H. Thru-Roof Hardware

1. Thru-roof penetrations shall have stainless steel nuts, bolts, and washers. Sealing washers and sealing boots shall be provided as required and shall be compatible with the roofing material. Conductor connections to this roof hardware shall be by bolted connection. Crimp type connections are not acceptable.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. The lightning protection system shall be furnished and installed in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the system components at time of shipment. The system components shall be suitably protected until accepted by the Owner.

B. The equipment shall be installed in accordance with the manufacturer's recommendations. This shall include, but not be limited to the following:

1. Course all main down conductors to maintain a downward or horizontal run free of pockets or sags. Maintain an eight-inch (8") minimum radius and make no bend greater than 90 degrees. Follow the most direct route with inductance bonding conductors maintaining the horizontal or downward course of the main conductor. Interconnect roof conductors to provide at least two paths to ground from each terminal and to form closed loops. Follow the most direct path possible with down conductors between roof conductors and ground terminals. All down conductors for new occupiable buildings shall be placed in a concealed manner. Down conductors for existing occupiable structures, tanks, basins, and other non-occupiable structures may be installed exposed.

2. Install ground connections at no less than 60-foot intervals and at each down conductor on perimeter. If the structure has a ground grid, the ground rods from that grid may be used for connection to the down conductors. At each ground connection, determine the extent of the grounding arrangement according to the volume and type of soil encountered and the lowest expected moisture content. Have the Owner's representative observe each ground connection. Bond together all electrical service, telephone service, and lightning protection grounds to all underground metallic piping systems as required by Article 250 of the NEC.

3. The structural steel frame (where provided) may substitute for main down conductors provided the frame is electrically continuous and of adequate cross-section. Where the steel frame is utilized, connect the roof conductor to steel at least as often and at the same column as the ground connections. Make connections to steel with exothermic welds wherever possible. Provide bonding as required to make the entire metal frame continuous.

4. Bond all sizable metal objects within 6-feet of down, roof, or grounding conductors to the system. Use only approved fittings and conductors.

5. Wherever possible problems with corrosion are encountered, use substitute approved materials and/or provide corrosion protection. Use bimetallic or other specially designed and approved connectors where dissimilar metals are to be joined.

6. Install air terminals within 2-feet of the edge of structure and at intervals not greater than 20-feet along perimeter and peak. Provide additional terminals to limit spacing across roof to 50-feet maximum. Bond any exposed metallic object or surface to the roof conductor. Flash all terminal or conductor penetrations in the roof to conform to the roofer's requirements.

7. Record each ground connection location and mark up a reproducible copy of the approved shop drawings with their location. Also, indicate any substantial field modifications on these drawings. These drawings shall be included in the O&M manual.

8. Log all continuity tests of metal framing, ground grid connections, bonding, and similar connections. Indicate the location of tests or plans. Include test results in the O&M manual.

9. Retain U.L. to make an inspection of the completed installation and issue a Master Label Certification. Furnish a copy of the Certification to the Owner upon receipt.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Certified Shop Tests and Reports

a. None Required.

2. Field Tests

a. After installation, the lightning protection system shall be tested for continuity to the ground grid. The tests shall be made by the lightning protection system installer. Test shall be as follows:

i. Record the resistance between each down conductor and the ground grid to ensure a suitable low-resistance connection. All resistance values shall be 1 ohm or less. Test shall be made after the ground grid has been installed and tested per the requirements of Section 16170, Grounding and Bonding.

-END OF SECTION-

SECTION 16800

PRE-FABRICATED EQUIPMENT CENTERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish, install, and place in satisfactory operation pre-fabricated equipment centers as specified herein and indicated on the Drawings. For this project, this specification applies to the Blower Electrical Power Center and the 27kV Switchgear Main Electrical Power Center.

B. Pre-fabricated equipment power centers shall be used to enclose equipment that is furnished under Division 16, and that equipment shall be as specified in its respective Section. Equipment furnished under other Divisions shall also be located in the pre-fabricated equipment power centers as shown on the Drawings.

Refer to the Contract Drawings for further details of equipment required to be located within these buildings. **It is the Contractor's responsibility to ensure each building is appropriately sized to include all equipment shown on the Contract Drawings and all equipment required to provide a complete and operable system.**

C. For the Blower Electrical Power Center, equipment specified elsewhere includes but is not limited to:

- Division 17 PLCs
- Division 11 Blower Control Panels
- Division 16 Switchboards
- Division 16 Panelboards and Transformers
- Division 16 RVSS Starters

D. For the 27kV Switchgear Main Electrical Power Center, equipment specified elsewhere includes but is not limited to:

- Division 16 Generator Controls
- Division 16 27kV Switchgear
- Division 16 Battery Systems
- Division 16 Panelboards and Transformer

E. Unless otherwise noted herein or on the Drawings, the Contractor shall be responsible for coordinating whether the electrical raceways and wire between equipment shown within the pre-fabricated equipment center will be furnished and installed by the equipment center manufacturer, or the Contractor's field personnel.

F. Reference Section 01350 Seismic Anchorage and Bracing; Section 01450 Special Inspections; Section 10400, Identifying Devices; Section 16000, Basic Electrical Requirements; Section 16111, Conduit; Section 16123, Low Voltage Cable; Section 16130, Boxes; Section 16141, Wiring Devices; Section 16500, Lighting; and Section 16670, Lightning Protection Systems.

1.02 CODES AND STANDARDS

A. Conformance

1. The building must be manufactured, inspected and approved in accordance with the State of South Carolina Modular Building Program requirements, including a certification label on the building issued by the South Carolina Building Codes Council.

2. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the latest edition of the National Electrical Code (NEC), the National Electric Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), the Insulated Cable Engineers Association (ICEA), the American Society of Testing Materials (ASTM), the American National Standards Institute (ANSI), the requirements of the Occupational Safety Hazards Act (OSHA), and all other applicable Federal, State and local laws and/or ordinances.

3. The structure design and manufacture shall, as a minimum, conform to ASCE (American Society of Civil Engineers) current edition of "Minimum Design Loads for Buildings and Other Structures" and to the MBMA (Metal Building Manufacturers Association) "Recommended Design Practices Manual." Building shall be manufactured and built to satisfy the current Editions of the International Building Code (IBC). Building Manufacturer shall supply plans and calculations stamped by a Registered Professional Engineer for the State of South Carolina, and is responsible for obtaining any Third Party Inspections if required, where building is installed.

4. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.

5. Loading - The building shall be designed, at a minimum to support the following loads:

   a. Roof Load - 50 PSF (40# live and 10# dead)

   b. Ceiling Dead Load - 10 PSF

   c. Wall Load - 130 mph wind, plus wall mounted equipment. See Sheet S000 for additional wind design requirements.

   d. Floor Load – 250 # PSF

   e. Seismic Zone: See Sheet S1 for seismic design criteria.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

3. Operation and Maintenance Manuals

4. Manufacturer's Representative's Installation Certification

5. Verification of AISC certification of fabricator.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

2. Detailed drawings as follows:

a. Drawings shall show plan, front, and side views as well as appropriate section views of the pre-fabricated equipment center.

b. Drawings shall be annotated with appropriate linear dimensions, identify any shipping split locations, and include the shipping weight for each section of the equipment center.

c. Drawings shall adequately detail the conduit stub-up areas below each piece of equipment.

d. Equipment center erection drawings showing comprehensive details of wall panels, roof panels, base and floor. Erection drawings shall include connection details and anchoring details.

e. Structural calculations of structural system for equipment center showing compliance with governing building code for all components, connections, and anchorage of system shall be submitted with detailed erection drawings. Calculations shall be sealed by a Professional Engineer currently registered in the State of South Carolina.

3. Product data sheets for all appurtenances and accessories (air conditioning unit, light fixture, etc.) that are furnished and installed within the equipment center.

4. Bill of material list.

5. Manufacturer's installation instructions.

6. Manufacturer's warranty statement.

7. Manufacturer's installation certification.

8. Calculations used to size air conditioning units.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

E. Final approval of shop drawings will not be granted until all equipment shown within the pre-fabricated equipment center has been reviewed and accepted by the Engineer.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books and/or leaflets.

2. All product data sheets previously included in the shop drawing submittals.

3. Final as-built layout drawing of the equipment center, incorporating all changes made during construction.

1.06 SPARE PARTS

A. The Contractor shall furnish the following spare parts:

No. Required	Description
4 sets	Air filters for each air conditioning unit
2 gallons	Paint for re-coating floor after construction is complete

1.07 IDENTIFICATION

A. Each pre-fabricated equipment center shall be identified with the name and/or number shown on the Drawings. A sign shall be provided on each door in accordance with Section 10400, Identifying Devices.

1.08 WARRANTY

A. The manufacturer's warranty shall in no event be for a period of less than three (3) years from date of delivery of equipment to the project site and shall include repair labor, travel expense necessary for repairs at the jobsite, and expendables used during the course of repair. Submittals received without written warranties as specified shall be rejected in their entirety.

B. The Contractor shall provide a complete warranty covering the equipment center structure as well as all accessories and appurtenances that are furnished and installed with the equipment center.

PART 2 – PRODUCTS

2.01 GENERAL

A. The equipment center shall be provided with length and width dimensions no less than those shown on the Drawings, but large enough to accommodate all equipment shown to be installed inside.

B. The equipment center shall designed to be split into sections as shown on the Drawings to be transported to the project site.

C. Equipment that is not specified to be provided under Division 16 (ex. PLC provided under Division 17) may also be shown to be located within the equipment center. Equipment center manufacturer is cautioned to properly coordinate the size of the equipment center and location of conduit stub-ups with the approved shop drawings for any equipment furnished outside of Division 16. **For example, the Blower Control Panels will be provided outside of Division 16, but will be physically located within the enclosure.**

2.02 EQUIPMENT CENTER STRUCTURE

A. Base and Floor

1. The base of the equipment center shall be constructed of welded steel I-beams, channels, and angle supports sized and reinforced to accommodate loading requirements. The height of the base steel shall be same around the entire outer perimeter of the equipment center to prevent debris and animals from getting under the base.

2. The base structure shall be designed to support the equipment center when installed on a concrete slab, piers, or a vault. Reference the Drawings for base support details.

3. The base shall be cleaned and epoxy painted after welding is complete. The entire underside of the base shall be coated with a minimum 8 mil bituminous mastic. Base paint color shall be ANSI 61 light gray.

4. The floor of the equipment center shall be constructed of ¼ inch thick (minimum) steel plate welded to the base framework. Floor material shall be painted tread plate to provide slip resistance, or flat steel coated with an enamel containing immersed sand. Floor paint color shall be ANSI 61 light gray.

5. All components of the base and floor shall be designed to withstand all applicable vertical and lateral loads in accordance with the requirements of the governing building code.

6. Anchorage of equipment center base to foundation slab or structure shall be designed and detailed by the equipment center manufacturer. Anchorage shall be designed to withstand all applicable vertical and lateral loads in accordance with the requirements of the governing building code.

B. Walls and Roof

1. Wall panel material shall be 12 gauge (minimum) aluminum or 14 gauge (minimum) galvanized steel formed in an interlocking design which is self-framing. No other material types are acceptable. Wall panels shall be capable of withstanding all applicable vertical and lateral loads in accordance with the requirements of the governing building code.

2. Roof panel shall be material shall be 12 gauge (minimum) aluminum or 14 gauge (minimum) galvanized steel formed in a standing rib design eliminating the possibility of water entry. No other material types are acceptable. Roof panels shall be capable of withstanding all applicable vertical and lateral loads in accordance with the requirements of the governing building code.

3. Interior and exterior of wall and roof panels shall be painted in a 6-mil (minimum) ANSI 61 light gray color.

C. Doors

1. Personnel Entry Doors

a. Entry doors shall be double-wall construction with tempered or laminated safety glass windows meeting CPSC 16 CFR 1201 or ANSI Z97.1. The safety glass window shall large enough to cover no less than 1/3 of the door surface.

b. Automatic door closers, cellular neoprene gaskets, panic hardware, threshold, and door bottom seal shall be provided for each door. Doors shall open outward.

c. Lockset hardware shall be provided for each door with cylinder to match the Owner's master key system. Coordinate keying with Owner.

d. Minimum single door size shall be 7 feet tall by 3 feet wide. Taller doors shall be provided as required for equipment installation/removal. Double doors shall be provided where indicated on the Drawings. Doors shall be provided with a continuous hinge or three ball bearing hinges for doors 7 feet tall and an additional ball bearing hinge for every additional 2 feet in door height.

2. Equipment Access Doors

a. Access doors for equipment located within the pre-fabricated equipment center shall be provided where indicated on the Drawings, and where required for outdoor access to rear-accessible equipment.

b. Equipment access doors shall be sized for the equipment that they serve and shall be provided with gaskets to maintain the rain-tight integrity of the enclosure.

c. Equipment access doors shall be hinged on one side, and have a pad-lockable 3-point latching system on the other side. Provide doors with wind-stop hardware.

D. Insulation

1. The underside of the floor shall be provided with rigid foam insulation or spray-foam insulation to achieve a minimum value of R11.

2. The walls and roof shall be provided with rigid foam or fiberglass batt insulation to achieve a minimum value of R20.

2.03 FEATURES

A. Lighting

1. Provide interior and exterior lighting fixtures in the quantities, types, and locations as shown on the Drawings. Lighting fixtures shall be as specified in Section 16500, Lighting.

2. Exterior lighting shall be provided over each personnel door. Exterior lighting shall be LED type with integral photocell.

3. Emergency and exit lighting shall be provided within the equipment center. Emergency lighting shall integral nickel-cadmium battery backup and provide illumination in accordance with NFPA-101, Life Safety Code. Exit fixtures shall be LED type and wall mounted over each equipment center personnel door.

B. Receptacles and Switches

1. Provide 3-way light switches at each personnel door to control the interior lighting of the equipment center.

2. Provide receptacles in the quantity and location as shown on the Drawings. If receptacles are not shown on the Drawings, a minimum of two receptacles shall be provided near each personnel door, one on the exterior and one on the interior of the equipment center.

3. Light switches and receptacles shall be as specified in Section 16141, Wiring Devices.

C. Raceways, Boxes, and Wiring

1. All conduit factory-installed within the interior of the equipment center shall be electrical metallic tubing (EMT). Conduit shall be furnished and installed in accordance with Section 16111, Conduit.

2. All cables and wiring factory-installed within the equipment center shall be furnished and installed in accordance with Section 16123, Low Voltage Wire and Cable.

3. Pull and junction boxes, furnished and installed in accordance with Section 16130, Boxes, shall be provided within the equipment center as required. Provide junction boxes on each side of an equipment center shipping split where factory-installed conduits need cross the split.

D. Climate Control

1. Calculations

a. The equipment center manufacturer shall perform calculations to determine the proper size of heating and air conditioning units for the equipment center. Calculations shall be submitted for review. The following parameters shall be used in the calculations:

i. 85 degree F maximum allowable indoor air temperature
ii. 55 degree F minimum allowable indoor air temperature
iii. Outdoor ambient high and low temperatures published in the ASHRAE Handbook for the location of equipment center installation
iv. Heat gain of all equipment within equipment center shall be calculated based on each piece of equipment operating at 75% of its full load.
v. Insulation R values as specified elsewhere herein

2. Heating Air Conditioning Units

a. Package heating and air conditioning units shall be provided in the location as indicated on the Drawings, and at the calculated size required. Two (2) units shall be provided, allowing for 100% redundancy of heating and cooling.

b. Heating and air conditioning units shall be factory wired to a 480V source located in the equipment center. Air conditioning units shall be provided with a Heresite phenolic coil coating for corrosion prevention.

c. If the calculated heat gain of the equipment within the equipment center is enough to keep the indoor air temperature above the allowable minimum, electric heating shall not be required to be provided as part of the heating and air conditioning unit.

3. An automatic temperature controller shall be provided as part of the heating and air conditioning system, factory wired to each unit, with the following features:

a. Temperature setpoint control and display

b. Controls to alternate the operation of each unit and equalize run times

c. DPDT contact rated 5A (minimum) at 120VAC to indicate air conditioning unit failure

d. DPDT contact rated 5A (minimum) at 120VAC to indicate a low air temperature inside the equipment center, with adjustable setpoint (initially set at 50 degrees F)

e. DPDT contact rated 5A (minimum) at 120VAC to indicate a high air temperature inside the equipment center, with adjustable setpoint (initially set at 95 degrees F)

E. Generator Connection Cabinet (See Specification 16497)

1. Generator connection cabinet shall be located on the exterior of the pre-fabricated equipment center for the Blower Electrical Building. Refer to the Contract Drawings for specific details regarding the receptacles.

2. The generator connection cabinet shall be hard-wired from the cabinet to the appropriate switchboard section. Physical location of switchboard section and location of external cabinet shall be coordinated during fabrication of the building.

F. Grounding

1. A stainless steel grounding attachment pad shall be welded to the exterior base on each corner of the equipment center. Pad shall be provided with a threaded hole to allow a one-hole wire lug to be affixed.

2. A tin-plated copper grounding bar shall be provided around the entire interior perimeter of the equipment center. Grounding bar shall be installed at a height just below the ceiling and shall be 2 inches tall by ¼ inch thick. Install a #4/0 AWG bare copper grounding electrode conductor from at least two points on the grounding bar through the floor and out to the grounding electrode or grounding electrode system shown on the Drawings.

G. Miscellaneous

1. Provide a fire extinguisher on the interior of the equipment center at each personnel door. Fire extinguisher shall be 10 lb. capacity, hand portable, carbon dioxide type, with Underwriters' Laboratories rating of 4-A: 60 BC.

PART 3 – EXECUTION:

3.01 INSTALLATION

A. Manufacturer shall acquire all necessary permits to transport the pre-fabricated equipment center through each state between the factory and project site.

B. If the equipment center is split into multiple pieces for shipping, the open ends of the equipment center shall be weatherproofed to protect the equipment inside during transport and re-assembly of the shipping sections.

C. Contractor shall furnish and install all anchoring required for the equipment center in accordance with the manufacturer’s instructions.

D. Exposed electrical raceways installed within the equipment center by the Contractor's field personnel shall be coordinated with the equipment center manufacturer to ensure the raceways can be properly supported in accordance with the NEC. Raceways shall be conduits, cable tray is not acceptable.

E. Exposed electrical raceways installed within the equipment center by the equipment center manufacturer shall be conduits, cable tray is not permitted.

F. Automatic door closers shall be adjusted after installation to prevent doors from slamming shut or taking an unnecessary amount of time to close.

G. At the conclusion of all work within the equipment center, the floor shall be thoroughly cleaned and repainted with the same paint used to initially coat the floor.

3.02 SERVICES OF A MANUFACTURERS REPRESENTATIVE

A. The Contractor shall provide the services of a qualified, factory-trained manufacturer's technical representative who shall adequately supervise the installation and/or assembly of the pre-fabricated equipment center. The manufacturer's representative shall certify in writing that the equipment center has been installed and/or assembled in accordance with the manufacturer's recommendations. No further work may be performed inside the equipment center until this certification is accepted by the Owner.

B. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of two (2) working days during the installation and/or assembly of the equipment center.

2. One (1) trip of one (1) working day two (2) months before the warranty expiration to identify any issues to be corrected under warranty.

C. Any additional time required to achieve successful installation shall be at the expense of the Contractor.

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SECTION 16902

ELECTRIC CONTROLS AND RELAYS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.

B. Electrical control and relay systems shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

C. Reference Section 16000, Basic Electrical Requirements and Section 16195, Electrical Identification.

1.02 CODES AND STANDARDS

A. Products specified herein shall be in conformance with or listed to the following standards as applicable:

1. NEMA 250 – Enclosures for Electrical Equipment

2. UL 508A – Standard for Industrial Control Panels

3. UL-1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.

4. ANSI/ISA 12.12.01-2013 – Nonincendive Electrical Equipment for use in Class I and II, Division II Hazardous (Classified) locations.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

B. Each submittal shall be identified by the applicable specification section.

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1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

PART 2 -- PRODUCTS

2.01 CONTROL COMPONENTS

A. Manufacturers

1. Control components shall be manufactured by Eaton, The Square D Company, General Electric, Allen-Bradley, Siemens Energy and Automation, or Engineer approved equal.

B. Pilot Devices

1. General

a. All pilot devices shall be provided with a legend plate. Legend plates shall have a white background and black lettering and indicate the function of the respective pilot device. The text shown on the Drawings or indicated in the specifications shall be used as the basis for legend plate engraving (i.e. HAND-OFF-AUTO, RUN, EMERGENCY STOP, etc).

b. All pilot devices shall be selected and properly installed to maintain the NEMA 250 rating of the enclosure in which they are installed. All pilot devices shall be UL 508 Listed.

c. All pilot devices shall be 30.5mm in diameter, unless otherwise indicated. 22mm devices are not acceptable.

d. Pilot devices for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

e. In Class 1 Division 2 hazardous locations, pilot devices shall be the hermetically-sealed type, constructed in accordance with ANSI/ISA 12.12.01.

2. Pushbuttons

a. Pushbuttons shall be non-illuminated, black in color, and have momentary style operation unless otherwise indicated on the Drawings.

b. Pushbuttons shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each pushbutton. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

c. Pushbuttons shall be provided with a full guard around the perimeter of the button. Where a lockout style pushbutton is specified or indicated on the Drawings, provide a padlockable guard.

3. Selector Switches

a. Selector switches shall be non-illuminated, black in color, and have the number of maintained positions as indicated on the Drawings and as required. Handles shall be the extended type that provide a greater surface area for operation.

b. Selector switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each selector switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

c. Where indicated in the Drawings or Specifications, provide spring return positions.

d. Selector switches shall be provided with an indexing component that fits into the keyed portion of the cutout for the device and prevents the switch from spinning when operated.

4. Indicating Lights

a. Indicating lights shall LED type, with the proper voltage rating to suit the application, and push-to-test feature.

b. Indicating light lens colors shall be as required in equipment specifications and/or as indicated on the Drawings. If lens colors are not indicated, the following colors shall be used:

i. Red - "Run", "On", “Open”

ii. Green - "Off", “Closed”

iii. Amber - "Alarm", "Fail"

iv. White - “Control Power On”

5. Emergency Stop and Tagline Switches

a. Emergency stop switches shall be non-illuminated, red in color, with a minimum 35mm diameter mushroom head. Once activated, switch shall maintain its position and require a manual pull to release/reset.

b. Tagline switches shall have a plunger that activates upon tension from the associated safety cable. Once activated, switch shall maintain its position and require a manual release/reset.

c. Emergency stop and tagline switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

C. Relays and Timers

1. General

a. Relays and timers shall be furnished with an integral pilot light for positive indication of coil energization.

b. Relays and timers shall have tubular pin style terminals with matching 11-pin DIN rail mount socket. Spade or blade style terminals are not acceptable.

c. Relays and timers for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

2. Control and Pilot Relays

a. Miniature or “ice-cube” type relays are not acceptable.

b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.

c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have 3-pole, double-throw (3PDT) contact arrangement.

3. Time Delay Relays

a. Timers delay relays shall utilize electronic timing technology. Mechanical timing devices are not acceptable.

b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.

c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have double-pole double-throw (DPDT) contact arrangement.

d. Time delay ranges shall be as indicated on the Drawings and/or as required to suit the application. Timing range shall be adjustable from the front of the relay. On delay and off delay timer configurations shall be provided as indicated on the Drawings and/or as required to suit the application.

4. Elapsed Time Meters

a. Elapsed time meters shall be non-resettable type with no less than a 4 digit display. Coil voltage shall be as required to suit the application and/or as indicated on the Drawings.

D. Control Terminal Blocks

1. Control terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or subpanel. Terminals shall be tubular screw type with pressure plate that will accommodate wire size range of #22 - #8 AWG.

2. Control terminal blocks shall be single tier with a minimum rating of 600 volts and 20A. Separate terminal strips shall be provided for each type of control used (i.e. 120VAC vs. 24VDC). Quantity of terminals shall be provided as required to suit the application. In addition, there shall be a sufficient quantity of terminals for the termination of all spare conductors.

3. Terminals shall be marked with a permanent, continuous marking strip, with each terminal numbered. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal.

2.02 LOCAL CONTROL STATIONS

A. Local control stations shall be furnished and installed complete with pushbuttons, selector switches, indicating lights, and other devices as indicated on the Drawings.

B. Specific devices installed in local control stations shall be provided in accordance with the requirements specified elsewhere in this Section.

C. In non-hazardous locations, local control stations shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Die Cast Zinc
Indoor Dry Non-process Area	NEMA 12, Die Cast Zinc
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

D. In hazardous locations, local control stations shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

AREA CLASSIFICATION	ENCLOSURE TYPE AND MATERIAL
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Type 304 Stainless Steel
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 9, Die Cast Aluminum

E. Non-metallic enclosures, NEMA 7 enclosures, and NEMA 9 enclosures shall be provided with threaded integral conduit hubs. Conduit hubs shall be external to the enclosure.

F. Local control stations for use in non-hazardous locations shall be UL-508 Listed. Local control stations for use in Class 1 Division 1 and Class 2 Divisions 1/2 hazardous locations shall be UL-1203 Listed. Local control stations for use in Class 1 Division 2 hazardous locations shall be in accordance with ANSI/ISA 12.12.01-2013.

G. Provide a nameplate on each local control station in accordance with Section 16195, Electrical Identification. The name and/or number of the equipment associated with each control station shall be engraved on the nameplate, followed by the words “LOCAL CONTROL STATION”.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Local control stations shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

B. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries' standard practices.

C. Pilot devices shall be properly bonded to the equipment enclosure door where they are installed. If proper bonding cannot be achieved through the locknuts that affix the device in place, a green colored bonding screw shall be provided on the pilot device. The bonding screw shall be bonded to the equipment enclosure through the use of an insulated green bonding conductor.

D. Local control station covers shall be bonded to the local control station enclosure through the use of an insulated green bonding conductor.

E. Wiring to devices at each local control station shall be provided with enough slack to permit the local control station cover to be removed and pulled at least 6 inches away from the enclosure.

F. Terminal strips, relays, timers, and similar devices shall not be installed on the rear of the panel/cabinet doors. Terminal strips, relays, timers, and similar devices shall not be installed on the side walls of panel/cabinet interiors without written permission from the Engineer.

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SECTION 17000

CONTROL AND INFORMATION SYSTEM
SCOPE AND GENERAL REQUIREMENTS

PART 1 -- GENERAL

1.01 SCOPE

A. The Contractor shall provide, through the services of an instrumentation and control system subcontractor, all components, system installation services, as well as all required and specified ancillary services in connection with the Instrumentation, Control and Information System. The System includes all materials, labor, tools, fees, charges and documentation required to furnish, install, test and place in operation a complete and operable instrumentation, control and information system as shown and/or specified. The system shall include all measuring elements, signal converters, transmitters, local control panels, digital hardware and software, operator workstations, remote telemetry units, signal and data transmission systems, interconnecting wiring and such accessories as shown, specified, and/or required to provide the functions indicated.

B. The scope of the work to be performed under this Division includes but is not limited to the following:

1. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.

2. Furnish and install process instrumentation and associated taps and supports as scheduled or shown on the Drawings, unless otherwise noted or supplied by equipment vendors.

3. Furnish and install local control panels, field panels and associated cabinets and panels as shown on the Drawings and as specified in Division 17.

4. Where existing panels are modified, the following shall be done:

a. Provide the required hardware and labor for installing all terminals, control system hardware, instrumentation devices, etc., including the termination of new signals in the existing panel.

b. Fully document existing control panels prior to any modifications. New components, sub-panels, etc., installed in the panel shall not block access to any existing instrumentation, control system hardware, or terminations. Existing documentation may not be completely correct. Determine the existing wiring, logic, and functionality with a combination of field investigation and communication with plant operation and maintenance personnel.

c. Provide nameplates, wire markers, wire duct, and additional devices and components to match existing.

5. Furnish and install digital control system hardware and software as specified in Division 17.

6. Final termination and testing of all instrumentation and control system signal wiring and power supply wiring at equipment furnished under Division 17.

7. Furnish, install and terminate all special cables (instruments, printers, telemetry, etc.). Furnish and terminate control system communication network cables.

8. Furnish and install surge protection devices for all digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division, including connections to grounding system(s) provided under Division 16.

9. Coordinate grounding requirements with the electrical subcontractor for all digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division. Terminate grounding system cables at all equipment provided under this Division.

10. Modify the existing SCADA system as shown in the drawings to accommodate changes to plant equipment, instrumentation and operations. Current IP addresses should be reused whenever practical for equipment and instrumentation that is being replaced in kind under this contract.

11. Furnish and install supervisory PLC to provide supervisory control logic for the aeration blowers and for aeration tank air flow control as shown on the Drawings and as described in Section 17950.

12. Furnish and install PLC in the Main Electrical Power Center to interface with electrical equipment as shown on the drawings and as described in Section 17950.

13. Furnish and install instrumentation for refitted Aeration Tanks 1 and 2 and the new aeration blower facility. Modifications to existing PLC-14 shall be provided as shown on the drawings and as described in Section 17950 to interface with aeration tank mixers.

14. Furnish and install instrumentation and control logic for level control of the new bypass gates in the junction structure. Modifications to existing PLC-06 shall be provided as shown on the drawings and as described in Section 17950.

15. Receive analog inputs from the existing TSS/NH_3/NO_3 analyzer for remote monitoring. The analyzer will remain in its current location.

16. Provide system testing, calibration, training and startup services as specified herein and as required to make all systems fully operational.

C. It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials that may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

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1.02 RELATED ITEMS

A. Field mounted switches, torque switches, limit switches, gauges, valve and gate operator position transmitters, sump pump controls and other instrumentation and controls furnished with mechanical or electrical equipment not listed in the instrument schedule shall be furnished, installed, tested and calibrated as specified under other Divisions.

B. Additional and related work performed under Division 16 includes the following:

1. Instrument A.C. power source and disconnect switch for process instrumentation, A.C. grounding systems, and A.C. power supplies for all equipment, control panels and accessories furnished under Division 17.

2. Conduit and raceways for all instrumentation and control system signal wiring, grounding systems, special cables and communication network cables.

3. Instrumentation and control system signal wiring.

4. Install control system communication network cables.

5. Furnish and install grounding systems for all digital equipment, local control panels, remote telemetry units, and instrumentation provided under Division 17. Grounding systems shall be complete to the equipment provided under Division 17, ready for termination by the instrumentation subcontractor.

6. Termination of all instrumentation and control system signal wiring at all equipment furnished under other divisions of the Specifications.

7. Final wiring and termination to A.C. grounding systems and to A.C. power sources (e.g. panelboards, motor control centers, and other sources of electrical power).

1.03 GENERAL INFORMATION AND DESCRIPTION

A. Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings.

B. In order to centralize responsibility, it is required that all equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating all signals, and furnishing all appurtenant equipment.

C. The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be

responsible for the delivery of all detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment and/or systems and shall provide for the services of a qualified installation engineer to supervise all activities required to place the completed facility in stable operation under full digital control.

D. The instrumentation and control system shall be capable of simultaneously implementing all real-time control and information system functions, and servicing all operator service requests as specified, without degrading the data handling and processing capability of any system component.

E. Control system inputs and outputs are listed in the Input/Output Schedule. This information, together with the functional control descriptions, process and instrumentation diagrams, and electrical control schematics, describes the real-time monitoring and control functions to be performed. In addition, the system shall provide various man/machine interface and data reporting functions as specified in the software sections of this Specification.

F. The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field-mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect all equipment, panels, instrumentation, controls and appurtenances either existing or furnished under other Divisions of the Specifications to determine all requirements to interface same with the control and information system. The Contractor shall coordinate the completion of any required modifications with the associated supplier of the item furnished.

G. The instrumentation subcontractor shall review and approve the size and routing of all instrumentation and control cable and conduit systems furnished by the electrical subcontractor for suitability for use with the associated cable system.

H. The Contractor shall coordinate the efforts of each supplier to aid in interfacing all systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the electrical subcontractor and to the instrumentation subcontractor furnishing the equipment under this Division.

I. The Contractor shall be responsible for providing a signal transmission system free from electrical interference that would be detrimental to the proper functioning of the instrumentation and control system equipment.

J. The Owner shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to inspect materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records and certifications during any stage of design, fabrication and tests. The instrumentation subcontractor and his equipment suppliers shall furnish office space, supplies and services required for these surveillance activities.

K. The terms "Instrumentation", "Instrumentation and Control System", and "Instrumentation, Control and Information System" shall hereinafter be defined as all equipment, labor, services and documents necessary to meet the intent of the Specifications.

1.04 INSTRUMENTATION AND CONTROL SYSTEM SUBCONTRACTORS

A. Instrumentation and control system subcontractors shall be regularly engaged in the detailed design, fabrication, installation, and startup of instrumentation and control systems for water and wastewater treatment facilities. Instrumentation and control system subcontractors shall have a minimum of five years of such experience and shall have completed a minimum of three projects of similar type and size as that specified herein. Where specific manufacturers and/or models of major hardware or software products (PLC, HMI software, LAN, etc.) are specified to be used on this project, the instrumentation and control system subcontractor shall have completed at least one project using that specified hardware or software. As used herein, the term “completed” shall mean that a project has been brought to final completion and final payment has been made. Any instrumentation and control system subcontractor that has been subject to litigation or the assessment of liquidated damages for nonperformance on any project within the last five calendar years shall not be acceptable.

B. Acceptable instrumentation and control system subcontractors shall be CITI, LLC; Custom Controls Unlimited, Inc.; Glenmount Global; M/R Systems, Inc.; Nix, Purser and Associates, Inc.; Piedmont Automation, Inc.; Revere Control Systems; Sunapsys, Inc.; Systems East, Inc.; Transdyn Controls, Inc.; Lord and Company; or equal.

1.05 DEFINITIONS

A. Solid State: Wherever the term solid state is used to describe circuitry or components in the Specifications, it is intended that the circuitry or components shall be of the type that convey electrons by means of solid materials such as crystals or that work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, mechanical relays, stepping motors or other devices will not be considered as satisfying the requirements for solid state components of circuitry.

B. Bit or Data Bit: Whenever the terms bit or data bit are used in the Specification, it is intended that one bit shall be equivalent to one binary digit of information. In specifying data transmission rate, the bit rate or data bit rate shall be the number of binary digits transmitted per second and shall not necessarily be equal to either the maximum pulse rate or average pulse rate.

C. Integrated Circuit: Integrated circuit shall mean the physical realization of a number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.

D. Mean Time Between Failures (MTBF): The MTBF shall be calculated by taking the number of system operating hours logged during an arbitrary period of not less than six months and dividing by the number of failures experienced during this period plus one.

E. Mean Time to Repair (MTTR): The MTTR shall be calculated by taking the total system down time for repair over an arbitrary period of not less than six months coinciding with that used for calculation of MTBF and dividing by the number of failures causing down time during the period.

F. Availability: The availability of a non-redundant device or system shall be related to its MTBF and MTTR by the following formula:

A = 100 x (MTBF/(MTBF + MTTR)) Percent

The availability of a device or system provided with an automatically switched backup device or system shall be determined by the following formula:

A = A2 + 1 - ((1-A1) x (1-A1))

where:

A1 = availability of non-redundant device or system
A2 = availability of device or system provided with an automatically switched backup device or system

G. Abbreviations: Specification abbreviations include the following:

A	-	Availability
ADC	-	Analog to Digital Converter
AI	-	Analog Input
AO	-	Analog Output
AVAIL	-	Available
BCD	-	Binary Coded Decimal
CSMA/CD	-	Carrier Sense Multiple Access/Collision Detect
CPU	-	Central Processing Unit
CRC	-	Cyclic Redundancy Check
CRT	-	Cathode Ray Tube
CS	-	Control Strategy
DAC	-	Digital to Analog Converter
DBMS	-	Data Base Management System
DI	-	Discrete Input
DMA	-	Direct Memory Access
DO	-	Discrete Output
DPDT	-	Double Pole, Double Throw
DVE	-	Digital to Video Electronics
EPROM	-	Erasable, Programmable Read Only Memory

FDM	-	Frequency Division Multiplexing
FSK	-	Frequency Shift Keyed
HMI	-	Human Machine Interface (Software)
I/O	-	Input/Output
LAN	-	Local Area Network
LDFW	-	Lead-Follow
MCC	-	Motor Control Center
MTBF	-	Mean Time Between Failures
MTTR	-	Mean Time To Repair
OS	-	Operating System
PAC	-	Programmable Automation Controller
PCB	-	Printed Circuit Board
PID	-	Proportional Integral and Derivative Control
PLC	-	Programmable Logic Controller
PROM	-	Programmable Read Only Memory
RAM	-	Random Access Memory
RDY	-	Ready
RMSS	-	Root Mean Square Summation
RNG	-	Running
ROM	-	Read Only Memory
RTU	-	Remote Telemetry Unit
SPDT	-	Single Pole, Double Throw
ST/SP	-	Start/Stop
TDM	-	Time Division Multiplexing
UPS	-	Uninterruptible Power Supply

H. To minimize the number of characters in words used in textual descriptions on CRT displays, printouts and nameplates, abbreviations may be used subject to the Engineer's approval. If a specified abbreviation does not exist for a particular word, an abbreviation may be generated using the principles of masking and or vowel deletion. Masking involves retaining the first and last letters in a word and deleting one or more characters (usually vowels) from the interior of the word.

1.06 ENVIRONMENTAL CONDITIONS

A. Instrumentation equipment and enclosures shall be suitable for ambient conditions specified. All system elements shall operate properly in the presence of telephone lines, power lines, and electrical equipment.

B. Inside control rooms and climate-controlled electrical rooms, the temperature will normally be 20 to 25 degrees C; relative humidity 40 to 80 percent without condensation and the air will be essentially free of corrosive contaminants and moisture. Appropriate air filtering shall be provided to meet environmental conditions (i.e., for dust).

C. Other indoor areas may not be air conditioned/heated; temperatures may range between 0 and 40 degrees C with relative humidity between 40 and 95 percent.

D. Field equipment including instrumentation and panels may be subjected to wind, rain, lightning, and corrosives in the environment, with ambient temperatures from -20 to 40 degrees C and relative humidity from 10 to 100 percent. All supports, brackets, interconnecting hardware, and fasteners shall be aluminum, type 316 stainless steel, or metal alloy as otherwise suitable for chemical resistance within chemical feed/storage areas shown on the installation detail drawings.

PART 2 -- PRODUCTS

2.01 NAMEPLATES

A. All items of equipment listed in the instrument schedule, control panels, and all items of digital hardware shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include the equipment identification number and description. Abbreviations of the description shall be subject to the Engineer's approval.

B. Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background.

C. Nameplates shall be attached to metal equipment by stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of stainless steel wire.

PART 3 -- EXECUTION

3.01 SCHEDULE OF PAYMENT

A. Payment to the Contractor for Control and Information System materials, equipment, and labor shall be in accordance with the General and Supplementary Conditions. The schedule of values submitted as required by the General and Supplementary Conditions shall reflect a breakdown of the work required for completion of the Control and Information System. The breakdown shall include sufficient detail to permit the Engineer to administer payment for the Control and Information System as outlined below.

B. The following payment schedule defines project milestones that will be used for establishing maximum partial payment amounts for the Control and Information System. Payment for field instruments, field wiring, fiber optic network cable and similar items will be made in addition to the payment for the scopes of services incorporated into the schedule below.

Task Completed	**Maximum Cumulative % Request for Payment**
Mobilization	3%
Preliminary Design Review	5%
Approved Submittals	20%
Hardware Purchase (excludes field instruments)	40%
Factory Acceptance Test	60%
Loop Checkout	70%
Control System Start-up and Test	80%
Plant Start-up	90%
Final System Acceptance Test	95%
Final Acceptance	100%

C. Requests for payment for materials and equipment that are not installed on site but are required for system construction and the factory acceptance test (e.g., digital hardware), or are properly stored as described in the General and Supplementary Conditions and herein shall be accompanied by invoices from the original supplier to the instrumentation subcontractor substantiating the cost of the materials or equipment.

D. Any balance remaining within the schedule of values for field instruments and other materials installed on the site, or for other materials for which payment is made by invoice, will be considered due upon completion of the Final Acceptance test.

3.02 CLEANING

A. The Contractor shall thoroughly clean all soiled surfaces of installed equipment and materials.

B. Upon completion of the instrumentation and control work, the Contractor shall remove all surplus materials, rubbish, and debris that has accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the Owner.

3.03 FINAL ACCEPTANCE

A. Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Engineer, and shall be based upon the following:

1. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.

2. Completion of the Availability Demonstration.

3. Completion of all specified control system training requirements.

4. Completion of all punch-list items that are significant in the opinion of the Engineer.

B. Final acceptance of the System shall mark the beginning of the extended warranty period.

- END OF SECTION -

SECTION 17030

CONTROL AND INFORMATION SYSTEM SUBMITTALS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall submit for review complete Shop Drawings for all equipment in accordance with the General Conditions and Division 1 of the Specifications. All submittal material shall be complete, legible, and reproducible, and shall apply specifically to this project.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Submittals

B. Section 17000 – Control and Information System Scope and General Requirements

1.03 DIGITAL HARDWARE SUBMITTALS

A. Submit system block diagram(s) showing:

1. All equipment to be provided.

2. All interconnecting cable.

3. Equipment names, manufacturer, and model numbers.

4. Equipment locations.

B. Submit information for all digital equipment including, but not limited to, the following:

1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.

2. Catalog cuts, including complete part number breakdown information.

3. Complete technical, material and environmental specifications.

4. Assembly drawings.

5. Mounting requirements.

6. Color samples.

7. Nameplates.

8. Environmental requirements during storage and operation.

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1.04 SOFTWARE SUBMITTALS

A. Software submittals shall include the following as a minimum:

1. Bill of materials with software names, vendors, and complete listings of included software modules.

2. Standard manufacturer's literature describing the products.

3. Description of function of software in Control and Information System.

4. Limitations or constraints of software.

5. Minimum system (processor and memory) requirements.

6. Operation and maintenance requirements.

B. Submit information on the following software:

1. Third-party software, including:

a. Operating system.

b. Operator workstation (SCADA or HMI) software, including all add-in software provided to perform specific functions (alarm dialers, schedulers, backup creation software, etc.).

c. Office-type products, such as spreadsheets, word processors, etc.

d. Database management software.

e. Communication software, including all applicable local and wide area network software.

f. Programmable controller programming software (where applicable).

2. Software configuration, including:

a. Graphic display organization.

b. Database configuration for operator workstations and database management system.

c. Trends.

d. System security.

e. Formats for all reports, including all required calculations.

f. Intercommunications between software products required to implement system functions.

g. Equipment backup configuration and requirements.

C. Control Strategies

1. Provide control strategy documentation that includes control strategy diagrams (block oriented logic and ladder logic diagrams, as appropriate) to describe the control of all processes. The written description shall follow the format of the functional control descriptions contained herein. The control strategy submittals shall contain the following as a minimum:

a. An overall description of the program structure and how it will meet the specified control requirements.

b. A listing of the program.

c. Extensive comments in the listings to describe program steps.

d. Equation and ladder program derivations for all specified control routines.

e. Resource (processor and memory) requirements.

f. A listing of inputs and outputs to the control strategy.

D. Application Software

1. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

2. Application software includes all custom routines developed specifically for this project, or pre-written routines used for accomplishing specified functions for this project. This shall include any add-in custom software.

E. Graphic Displays

1. Submit all graphic displays required to perform the control and operator interface functions specified herein.

2. Submit the complete set of graphic displays for review by the Owner and the Engineer at least 60 days prior to commencement of factory testing.

3. Where a large number of graphic displays are required, submit an initial set of example displays for review before the complete set of displays is submitted. This initial set shall include examples of all basic graphic display design features and parameters, and is intended to allow the Contractor to obtain preliminary approval of these features and parameters prior to beginning main graphic display production.

4. The Contractor shall allow for one major cycle of revisions to the displays prior to factory testing and one minor cycle of revisions following factory test. A cycle of revisions shall be defined as all revisions necessary to complete a single set of changes marked by the Engineer and the Owner. Additional corrections shall be performed during start-up as required to accommodate changes required by actual field conditions, at no additional cost to the Owner.

5. Two of the required submittals in each revision cycle shall be full color prints of the entire set of displays. Additional sets may be in black-and-white or gray-scale.

6. Displays shall be printouts of actual process graphics implemented in the system.

1.05 CONTROL PANEL SUBMITTALS

A. Submittals shall be provided for all control panels, and shall include:

1. Exterior panel drawings with front and side views, to scale.

2. Interior layout drawings showing the locations and sizes of all equipment and wiring mounted within the cabinet, to scale.

3. Panel area reserved for cable access and conduit entry.

4. Location plans showing each panel in its assigned location.

B. Submit information for all exterior and interior panel mounted equipment including, but not limited to, the following:

1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.

2. Catalog cuts, including complete part number breakdown information.

3. Complete technical, material and environmental specifications.

4. Assembly drawings.

5. Mounting requirements.

6. Color samples.

7. Nameplates.

8. Environmental requirements during storage and operation.

C. Submit panel wiring diagrams showing power, signal, and control wiring, including surge protection, relays, courtesy receptacles, lighting, wire size and color coding, etc.

1.06 INSTRUMENT SUBMITTALS

A. Submit information on all field instruments, including but not limited to the following:

1. Product (item) name and tag number used herein and on the Contract Drawings.

2. Catalog cuts, including complete part number breakdown information.

3. Manufacturer's complete model number.

4. Location of the device.

5. Input - output characteristics.

6. Range, size, and graduations.

7. Physical size with dimensions, NEMA enclosure classification and mounting details.

8. Materials of construction of all enclosures, wetted parts and major components.

9. Instrument or control device sizing calculations where applicable.

10. Certified calibration data on all flow metering devices.

11. Environmental requirements during storage and operation.

12. Associated surge protection devices.

1.07 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall deliver equipment operation and maintenance manuals in compliance with Section 01300 - Submittals. Operation and maintenance (O&M) manuals shall consist of two basic parts:

1. Manufacturer standard O&M manuals for all equipment and software furnished under this Division.

2. Custom O&M information describing the specific configuration of equipment and software, and the operation and maintenance requirements for this particular project.

B. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All modifications to manufacturer standard equipment and/or components shall be clearly identified and shown on the drawings and schematics. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

C. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operation and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include troubleshooting data and full preventive maintenance schedules. The instructions shall be bound in locking 3-D-ring binders with bindings no larger than 3.5 inches. The manuals shall include 15% spare space for the addition of future material. The instructions shall include drawings reduced or folded and shall provide the following as a minimum.

1. A comprehensive index.

2. A functional description of the entire system, with references to drawings and instructions.

3. A complete "as-built" set of all approved shop drawings, which shall reflect all work required to achieve final system acceptance.

4. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data.

5. Full specifications on each item.

6. Detailed service, maintenance, and operation instructions for each item supplied.

7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

8. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier.

9. References to manufacturers' standard literature where applicable.

10. Warning notes shall be located throughout the manual where such notes are required to prevent accidents or inadvertent misuse of equipment.

D. The operating instructions shall clearly describe the step-by-step procedures that must be followed to implement all phases of all operating modes. The instructions shall be in terms understandable and usable by operating personnel and maintenance crews and shall be useful in the training of such personnel.

E. The maintenance instructions shall describe the detailed preventive and corrective procedures required, including environmental requirements during equipment storage and system operation, to keep the System in good operating condition. All hardware maintenance documentation shall make reference to appropriate diagnostics, where applicable, and all necessary wiring diagrams, component drawings and PCB schematic drawings shall be included.

F. The hardware maintenance documentation shall include, as a minimum, the following information:

1. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.

2. Preventive-Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.

3. Corrective-Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card-replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.

4. Parts Information - This information shall include the identification of each replaceable or field-repairable component. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross-references between equipment numbers and manufacturer's part numbers shall be provided.

G. Software documentation shall conform to a standard format and shall include, but not be limited to, the following:

1. A program abstract that includes:

a. Program Name - The symbolic alphanumeric program name.

b. Program Title - English text identification.

c. Program Synopsis - A brief text shall be provided that specifies the need for the program, states when it shall be used and functionally describes all inputs, outputs and functions performed. This descriptive text shall be written in a language that is understandable by nonsoftware oriented readers.

2. A program description that shall include, but not be limited to, the following:

a. Applicable Documents - List all documents (standard manufacturer's literature, other program descriptions, etc.) by section, if practical, that apply to the program. One complete copy of all applicable reference material shall be provided.

b. Input-Output - Identify each input and output parameter, variable, and software element used by the program. State the purpose of all inputs, outputs, and variables.

c. Processing - This section shall contain a description of the overall structure and function of the program. Describe the program run stream and present a detailed description of how the program operates. Describe the timing and sequencing of operations of the program relative to other programs. Describe all interactions with other programs. Processing logic that is not readily described without considerable background information shall be handled as a special topic with references to an appendix or to control strategy document that details the necessary information. Reference shall also be made to an appendix or control strategy document for equation and program algorithm derivations.

d. System Configuration - Describe in detail the system configuration or status required for program implementation, if appropriate.

e. Limitations and Constraints - Summarize all known or anticipated limitations of the program, if appropriate.

f. Storage - Define program storage requirements in terms of disk or RAM memory allocation.

g. Verification - Describe, as a minimum, a test that can be used by the operator to assure proper program operation. Define the required system configuration, input requirements and criteria for successful test completion.

h. Diagnostics - Describe all program diagnostics, where applicable. Descriptions shall list each error statement, indicate clearly what it means, and specify what appropriate actions should be taken.

i. Malfunction Procedures - Specify procedures to follow for recovering from a malfunction due to either operator error or other sources.

1.08 FINAL SYSTEM DOCUMENTATION

A. All documentation shall be delivered to the Owner prior to final system acceptance in accordance with the Contract Documents. As a minimum, final documentation shall contain all information originally part of the control system submittals.

B. If any documentation or other technical information submitted is considered proprietary, such information shall be designated. Documentation or technical information which is designated as being proprietary will be used only for the construction, operation, or maintenance of the System and, to the extent permitted by law, will not be published or otherwise disclosed.

C. Provide a complete set of detailed electrical interconnection diagrams required to define the complete instrumentation and control system. All diagrams shall be 11 X 17-inch original reproducible prints. All diagrams shall be corrected so as to describe final "as-built" hardware configurations and to reflect the system configuration and control methodology adopted to achieve final system acceptance.

D. Provide system software documentation for the operation and maintenance of all system software programs provided as a part of the digital system. All system software documentation shall be amended as required to delineate all modifications and to accurately reflect the final as-built software configurations.

E. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

F. Provide control strategy documentation which shall include control strategy (block oriented or ladder logic) diagrams to describe the control of all processes. Control strategy documentation shall reflect the system configuration and control methodology adopted to achieve final system acceptance. Control strategy documentation shall conform to the submittal requirements listed hereinabove.

G. O&M documentation shall be amended with all final, adjusted values for all setpoints and other operating parameters for Owner reference.

H. The Owner recognizes the fact that not all possible problems related to real-time events, software interlocks, and hardware maintenance and utilization can be discovered during the Acceptance Tests. Therefore, the instrumentation subcontractor through the Contractor shall investigate, diagnose, repair, update, and distribute all pertaining documentation of the deficiencies that become evident during the warranty period. All such documentation shall be submitted in writing to the Owner within 30 days of identifying and solving the problem.

1.09 PROGRAMS AND SOURCE LISTINGS

A. Provide one copy of all standard, of-the-shelf system and application software (exclusive of firmware resident software) on original media furnished by the software manufacturer.

B. Provide one copy of source listings on optical media for all custom software written specifically for this facility, all database files configured for this facility, and all control strategies. All source listings shall include a program abstract, program linkage and input/output data. Comments describing the program flow shall be frequently interspersed throughout each listing.

1.10 SUBMITTAL/DOCUMENTATION FORMAT

A. All drawing-type submittals and documentation shall be rendered and submitted in the latest version of AutoCAD.

B. All textual-type submittals and documentation shall be rendered and submitted in the latest version of Microsoft Word or in Searchable Adobe Portable Document Format (.pdf).

1.11 ELECTRONIC O&M MANUALS

A. Subject to acceptance by the Owner and Engineer, the O&M information may be submitted in part or in whole in an electronic format on optical media.

B. Electronic O&M manuals shall contain information in standard formats (Searchable Adobe PDF, Word, AutoCAD, HTML, etc.) and shall be easily accessible through the use of standard, “off-the-shelf” software such as an Internet browser.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 17040

CONTROL AND INFORMATION SYSTEM TRAINING REQUIREMENTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. To familiarize the Owner's personnel with the process control system and field instrumentation, training shall be provided as detailed hereunder.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

1.03 SUBMITTALS

A. A minimum of 60 days prior to beginning training, submit a detailed training plan describing the following:

1. A listing of all courses to be conducted.

2. Course content.

3. Applicability of each course to management, operations, maintenance, laboratory, etc., personnel.

4. Course schedules.

5. Qualifications and experience of individual(s) providing training.

B. A minimum of 14 days prior to beginning each training course, submit documentation for use by the Owner's personnel during training. The training documentation shall be specific to the particular course, and shall include the following:

1. A listing of all subjects to be covered.

2. Course schedule.

3. Documentation/lesson plans covering all subjects to be covered during the course instruction. Information shall be in a "how to" format, with sufficient background documentation and references to manufacturer literature to provide a thorough and clear understanding of the materials to be covered.

1.04 GENERAL REQUIREMENTS

A. All costs of providing the training courses shall be borne by the Contractor.

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B. As used herein, the term "day" shall mean an eight-hour day, and the term "week" shall mean a five-day, 40-hour week.

C. Training courses, especially those for operator training, may be required to be scheduled during non-standard business hours (i.e., not between the hours of 8:00 am and 5:00 pm) to accommodate the working schedule of the Owner's personnel. No additional compensation will be awarded to the Contractor for training at non-standard hours.

D. All training courses shall complement the experience and skill levels of the Owner's personnel.

E. Training courses shall be structured in order of increasing capability or security levels. The purpose of this requirement is to allow personnel with lesser training requirements or security password levels to drop out of the training at certain times while the training continues for personnel with greater requirements or higher security levels.

F. All training courses shall include lecture as well as "hands on" experience for each of the attending personnel. The Contractor shall provide sufficient equipment for this to be accomplished. For example, training in which the instructor uses the computer and the Owner's personnel passively observe as the instructor demonstrates system functions shall not be acceptable.

G. Unless otherwise specified, all training courses shall be conducted in the Owner's facilities.

H. All training shall be completed prior to system acceptance.

I. Standard manufacturer training courses are acceptable pending approval by the Engineer and Owner.

1.05 SYSTEM SUPERVISOR/ENGINEER TRAINING

A. Provide manufacturer standard training in the use and configuration of the specified operator workstation (HMI or SCADA) software.

B. System supervisor/engineer training shall be performed a minimum of 30 days prior to system startup.

C. Training shall be provided in the following subjects:

1. System overview and capabilities.

2. Database configuration.

3. Graphic display configuration, including linking of data to displays.

4. Historical data configuration (collection, manipulation, and display).

5. Real-time and historical trending.

6. Report configuration, generation, printing, and customization.

7. Alarm configuration and management.

8. System security.

9. I/O driver use and configuration.

10. System backup and recovery.

11. DDE linking, where applicable.

12. System command language.

13. Troubleshooting.

14. System optimization.

15. System startup and shutdown procedures.

16. LAN and WAN communications, as appropriate.

D. The course shall be structured as follows:

1. Fundamentals - One four-day course (minimum) shall be provided for up to eight persons which shall serve as a digital control system familiarization course for project management personnel, engineers, and key operating/maintenance personnel. This course shall be a prerequisite for the advanced course described below in Item 2.

2. Advanced - One four-day (minimum) digital system configuration and operating course shall be provided for up to four persons. The level of training shall be sufficient to familiarize the Owner's personnel with the configuration and application of all system programs. All essential system operating procedures shall be described as required to enable the Owner's personnel to operate the system via the various workstations and local control panels.

3. Historical – One two-day course to instruct a minimum of four persons in the use and configuration of the historical data archival system. Training shall include creation, viewing, and printing of trends, charts, and reports. Training shall include all database maintenance and archival functions necessary to maintain the facility’s data on both short and long term basis, including periodic archival to optical media.

1.06 OPERATOR TRAINING

A. Two two-week courses comprised of daily half-day (four-hour) sessions for up to ten persons each shall be conducted to provide instruction in the use of the Control and Information System to monitor and control the facility.

B. Operator training shall include familiarization training covering the Control and Information System. Operators shall be instructed in the names, locations, functions, and basic operation of all items of digital equipment and associated software.

C. Operator training shall cover process and equipment operation both individually and collectively as an operating system. Normal as well as abnormal operating conditions shall be covered, including the response to failure occurrences and system alarms. All operator/system interactions shall be described.

D. Operators shall be trained to instruct other operators and shall be provided with all course materials.

1.07 MAINTENANCE TRAINING

A. A three-day course shall be conducted for at least six persons prior to the start-up of digital equipment at the Owner's plant. Instruction shall be provided in the following:

1. Operating all digital equipment, including system start-up and shutdown procedures.

2. The use of hardware diagnostic routines, test equipment and test procedures as required to enable the Owner's personnel to detect and isolate system faults to the circuit board or module level and to implement repairs by replacing failed circuit boards or modules.

3. Calibration and routine maintenance procedures for all analog and digital equipment.

B. Step by step written procedures shall be provided for all preventive maintenance tasks and for identifying hardware faults to the circuit board or module level for all items of digital equipment.

C. All digital equipment preventive and corrective maintenance training activities shall be limited to the use of commercially available off-the-shelf test equipment and to the use of diagnostic routines and hardware items which are the same as those to be provided as part of the system.

1.08 INSTRUMENT TRAINING

A. A three-day course shall be provided at the Owner's facilities no more than three months prior to system start-up to instruct a minimum of five persons each in the calibration and preventive maintenance of the field instruments provided under this Contract.

1.09 PLC TRAINING

A. One minimum three-day manufacturer standard training course shall be provided in the programming and use of PLC's to implement monitoring and control functions such as those provided for this project. Training shall cover all aspects of the PLC hardware and software, including specified programming software. This training shall be provided by the PLC manufacturer or, as directed by the manufacturer, by the authorized distributor engaged by the manufacturer to perform this training.

B. One three-day course of specific training shall be provided by the instrumentation subcontractor in the use and modification of all control strategies provided under this Division.

1.10 GENERAL REFRESHER TRAINING

A. A one-week general refresher training course shall be provided for up to ten persons 3-6 months after final system acceptance. Instruction shall be given in all aspects of the complete instrumentation and control system. Instructor(s) shall be capable of answering questions related to all aspects and details of the complete system.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 17060

SIGNAL COORDINATION REQUIREMENTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall conform to the signal coordination requirements specified herein.

B. The Contractor shall be responsible for coordinating signal types and transmission requirements between the various parties providing equipment under this Contract. This shall include, but not be limited to, distribution of appropriate shop drawings among the equipment suppliers, the electrical subcontractor, the HVAC subcontractor, and the instrumentation subcontractor.

C. Analog signals shall be signals for transmitting process variables, etc. from instruments and to and from panels, equipment PLC's and Control System PLC's.

D. Discrete signals shall consist of contact closures or powered signals for transmitting status/alarm information and control commands between starters, panels, equipment PLC's, the Control System, etc.

1.02 ANALOG SIGNAL TRANSMISSION

A. Signal transmission between electric or electronic instruments, controllers, and all equipment and control devices shall be individually isolated, linear 4-20 milliamperes and shall operate at 24 volts D.C.

B. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating.

C. All cable shields shall be grounded at one end only, at the control panel, with terminals bonded to the panel ground bus.

D. Analog signal isolation and/or conversion shall be provided where necessary to interface with instrumentation, equipment controls, panels, and appurtenances.

E. Non-standard transmission systems such as pulse duration, pulse rate, and voltage regulated shall not be permitted except where specifically noted in the Contract Documents. Where transmitters with nonstandard outputs do occur, their outputs shall be converted to an isolated, linear, 4-20 milliampere signal.

F. The Contractor shall provide 24 V power supplies for analog signals and instruments where applicable and as required inside panels, controls, etc.

G. Where two-wire instruments transmit directly to the Control and Information System, the instrumentation subcontractor shall provide power supplies at the PLC-equipped control panels for those instruments.

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H. Where four-wire instruments with on-board loop power supplies transmit directly to the Control and Information System, the instrumentation subcontractor shall provide necessary signal isolators or shall otherwise isolate the input from the Control and Information System loop power supply. Similar provisions shall be made when a third element such as a recorder, indicator, or single loop controller with integral loop power supply is included in the loop.

1.03 DISCRETE INPUTS

A. All discrete inputs to equipment and Control and Information System PLC's, from field devices, starters, panels, etc., shall be unpowered (dry) contacts in the field device or equipment, powered from the PLC's, unless specified otherwise.

B. Sensing power (wetting voltage) supplied by the PLC shall be 24 VDC.

1.04 DISCRETE OUTPUTS

A. All discrete outputs from local control panels and Control and Information System PLC's to field devices, starters, panels, etc., shall be 24 VDC powered (sourced) from PLC's.

B. PLC powered discrete outputs shall energize 24 VDC pilot relay coils in the field devices, starters, panels, etc. which in turn open or close contacts in the associated control circuit. The 24 VDC relay coil, contacts, and associated control circuitry shall be furnished integral with the field device, starter, panel, etc. by the supplier and contractor furnishing the field device, starter, or panel.

C. Where required or specified herein, discrete outputs from equipment and Control and Information System PLC's to field devices, starters, panels, motor operated valves, etc., shall be dry contact or relay outputs.

D. Outputs to solenoid valves shall be 120 VAC, powered from the PLC or control panel unless specified or shown otherwise.

1.05 OTHER DISCRETE SIGNALS

A. Discrete signals between starters, panels, etc. where no 24 VDC power supply is available may be 120 VAC, as long as such contacts are clearly identified in the starter, panel, etc. as being powered from a different power supply than other starter/panel components.

B. Where applicable, warning signs shall be affixed inside the starter, panel, etc. stating that the panel is energized from multiple sources.

C. Output contacts in the starter, panel, etc., that are powered from other locations shall be provided with special tags and/or color-coding. Disconnecting terminal strips shall be provided for such contacts.

D. The above requirements shall apply to all starters and panels, regardless of supplier.

PART 2 -- PRODUCTS

2.01 PILOT RELAYS

A. Pilot relays shall be supplied with the following:

1. 24 VDC or 120 VAC coils, as required.

2. At a minimum, DPDT contacts rated at 5 A, 120 VAC or 28 VDC.

3. Sockets for 24 VDC and 120 VAC relays shall be of different configurations.

4. Clips for attachment to sockets.

5. Indicator lights that glow when the relay coil is powered.

B. Pilot relays shall be as manufactured by Square D, Allen Bradley, Potter & Brumfield, or equal.

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 17070

CONTROL AND INFORMATION SYSTEM TESTING - GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall test the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17071 – Factory Acceptance Test

C. Section 17072 – Field Testing

D. Section 17073 – Final Acceptance Test

1.03 SUBMITTALS

A. For each of the specified tests, submit a test plan to the Engineer at least one month in advance of commencement of the tests. The test plan shall contain the following at a minimum:

1. A schedule of all testing to be conducted.

2. A brief description of the testing to be performed

3. Test objectives.

4. Testing criteria per the Specifications.

5. Check lists and procedures for performing each of the specified tests.

6. Sample test result documentation.

7. Requirements for other parties.

1.04 GENERAL REQUIREMENTS

A. All system start-up and test activities shall follow detailed test procedures; check lists, etc., previously approved by the Engineer. The Engineer shall be notified at least 21 days in advance of any system tests and reserves the right to have his and/or the Owner's representatives in attendance.

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B. The Contractor shall provide the services of experienced factory trained technicians, tools and equipment to field calibrate, test, inspect, and adjust all equipment in accordance with manufacturer's specifications and instructions.

C. The Contractor (or designee) shall maintain master logbooks for each phase of installation, startup and testing activities specified herein. Each logbook shall include signal, loop or control strategy tag number, equipment identification, description and space for sign-off dates, Contractor signature and Engineer signature. Example test documentation specific to each phase of testing shall be approved prior to initiation of that testing, as specified hereinabove.

D. All test data shall be recorded on test forms, previously approved by the Engineer. When each test has been successfully completed, a certified copy of all test results shall be furnished to the Engineer together with a clear and unequivocal statement that all specified test requirements have been met and that the system is operating in accordance with the Contract Documents.

E. The Engineer will review test documentation in accordance with the Contract Documents and will give written notice of the acceptability of the tests within 10 days of receipt of the test results.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 17071

FACTORY ACCEPTANCE TEST

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall perform a Factory Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17070 – Control and Information System Testing, General

C. Section 17072 – Field Testing

D. Section 17073 – Final Acceptance Test

1.03 FACTORY ACCEPTANCE TEST

A. The Control and Information System equipment shall not be shipped until the Contractor receives notice of acceptability of the factory tests.

B. Each item of equipment shall be fully factory inspected, calibrated and tested for function, operation and continuity of circuits. Exceptions shall be approved in writing by the Engineer.

C. Each subsystem shall be fully factory tested for function and operation.

D. System performance shall be tested using a fully integrated system, including all software and hardware. To achieve this, the entire control system, including all peripheral devices and all interconnecting cables (field instruments are not included in this requirement), shall be assembled on the factory test floor and the complete operational program loaded and simulated inputs applied.

E. All hardware and software required to perform the specified testing shall be furnished by the Contractor at no additional cost to the Owner.

F. The instrumentation subcontractor shall perform a 100-hour full system test, during which the entire system shall operate continuously without failure in accordance with the requirements of the Contract Documents. If a system component fails during the test, the 100-hour test period shall be restarted after its operation is restored.

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G. The factory testing shall demonstrate all aspects of system sizing and timing including:

1. Monitoring and control scan times at the PLC level.

2. Response times at the operator workstation level.

H. The overall system as well as individual component hardware shall be tested under conditions of power failure to ensure proper response as specified herein.

I. Operator Workstation Operation - This demonstration shall provide proof of system operation on an individual subsystem basis first, and then in the expected operating environment. Both normal and abnormal operating modes shall be demonstrated. Operator workstation testing shall include the following:

1. Demonstrate proper operation, under both normal and abnormal conditions of the operator workstation application software (SCADA, remote alarm dial-up, etc.). This shall include demonstration of system on-line diagnostics, fail-over features, reconfiguration operations, system initialization and restart, software fault tolerance, error detection and recovery, communications, and all additional features necessary to assure the successful operation of the system.

2. Demonstrate the standard features of the system. This shall include proof of operation of the process control database generator, the display generator, data storage and retrieval functions, data acquisition and control, trending functions, and reporting functions.

3. Demonstrate the configuration of the system to verify conformance with the Contract Documents. This shall include graphic displays and vectoring, operator interface functions, trending, reports, alarm management, security system configuration, etc.

4. The system shall be operated with data input/output with the PLC's and associated panels to prove operation of all workstation functions.

5. The testing in Items 2 and 3 above may be performed concurrently (i.e., the standard and configured features of the system may be demonstrated simultaneously).

J. PLC Operation - All functions comparable to those demonstrated for the operator workstations shall be demonstrated on the PLC's. This shall include the following:

1. On-line and off-line diagnostics.

2. For redundant units, fail-over operation and reconfiguration.

3. System initialization and restart.

4. Network communications, including fieldbus communications where required.

5. Non-volatility of memory.

6. Operation of all control logic shall be demonstrated as described herein.

K. Process I/O Simulation - Process input/output simulation for PLC's shall be performed with a manual simulation control panel, a separate programmable logic controller, network-based simulation software, analog signal generators, and/or jumpering of discrete signals between outputs and associated inputs, or some combination of these. Alternate process I/O systems such as plug-in circuit cards or I/O test modules may be utilized subject to approval by the Engineer to provide the specified simulation functions. The simulation system shall provide analog and discrete I/O hardware devices in sufficient quantity to allow complete and thorough testing of the control strategies and functions of the system. The process I/O simulation system shall be used in several ways as follows:

1. To provide a means of communications checkout from the operator workstations through the various levels of software in the PLC's and to the process, i.e., the simulation panel. Likewise, a discrete or analog input shall be initiated from the simulation panel and the result monitored at the workstations.

2. Alarm response to discrete status changes or analog value limits shall be verified. Database entries or attributes such as engineering units and conversion equations shall be verified by varying analog inputs.

3. To provide data for use at all levels of the control system at the time of system integration.

L. Control Strategy Testing - Provision shall be made to test all control strategies to prove the integrity of each strategy and the process control language in which it is implemented. For each control strategy, all functions shall be tested individually (where possible) and collectively to verify that the control strategy performs as described herein and as required for overall functionality within the control system.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 17072

FIELD TESTING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall perform field testing on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17070 – Control and Information System Testing, General

C. Section 17071 – Factory Acceptance Test

D. Section 17073 – Final Acceptance Test

1.03 GENERAL REQUIREMENTS

A. Control system start-up and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:

1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified in Sections 17600, 17700, and 17800.

2. Each final control element shall be individually tested as specified hereinafter.

3. Each control loop shall be tested as specified hereinafter.

4. Each control strategy shall be tested under automatic digital control as specified hereinafter.

5. The entire control system shall be tested for overall monitoring, control, communication, and information management functions, and demonstrated for system availability as specified hereinafter.

B. System start-up and test activities shall include the use of water, if necessary, to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

C. Each phase of testing shall be fully and successfully completed and all associated documentation submitted and approved prior to the next phase being started. Specific exceptions are allowed if written approval has been obtained in advance from the Engineer.

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1.04 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor shall ensure that all mechanical equipment, equipment control panels, local control panels, field instrumentation, control system equipment and related equipment and/or systems are tested for proper installation, adjusted and calibrated on a loop-by-loop basis prior to control system startup to verify that each is ready to function as specified. Each test shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

B. The Contractor shall be responsible for coordination of meetings with all affected trades. A meeting shall be held each morning to review the day's test schedule with all affected trades. Similarly, a meeting shall be held each evening to review the day's test results and to review or revise the next day's test schedule as appropriate.

C. The Contractor shall ensure that the electrical subcontractor conforms to the start-up, test and sign-off procedures specified herein to assure proper function and coordination of all motor control center control and interlock circuitry and the transmission of all discrete and/or analog signals between equipment furnished by the electrical subcontractor and the control system specified herein.

D. The Contractor shall ensure that the HVAC subcontractor conforms to the start-up, test and sign-off procedures specified herein to assure proper function of all HVAC system control and interlock circuitry and the transmission of all discrete and/or analog signals between HVAC equipment and controls and the control system specified herein.

1.05 FINAL CONTROL ELEMENT TESTING

A. The proper control of all final control elements shall be verified by tests conducted in accordance with the requirements specified herein.

B. All modulating final control elements shall be tested for appropriate speed or position response by applying power and input demand signals and observing the equipment for proper direction and level of reaction. Each final control element shall be tested at 0, 25, 50, 75, and 100 percent of signal input level and the results checked against specified accuracy tolerances. Final control elements, such as VFD's, that require turndown limits shall be initially set during this test.

C. All non-modulating final control elements shall be tested for appropriate position response by applying and simulating control signals, and observing the equipment for proper reaction.

1.06 LOOP CHECKOUT

A. Prior to control system startup and testing, each monitoring and control loop shall be tested on an individual basis from the primary element to the final element, including the operator workstation or loop controller level, for continuity and for proper operation and calibration.

B. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.

C. The accuracy of all DAC's shall be verified by manually entering engineering unit data values at the operator workstation and then reading and recording the resulting analog output data.

D. The accuracy of all ADC's shall be verified using field inputs or by manually applying input signals at the final controller, and then reading and recording the resulting analog input data at the operator workstation.

E. Each loop tested shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

1.07 CONTROL SYSTEM STARTUP AND TESTING

A. Control system startup and testing shall be performed to demonstrate complete compliance with all specified functional and operational requirements. Testing activities shall include the simulation of both normal and abnormal operating conditions.

B. All digital hardware shall be fully inspected and tested for function, operation and continuity of circuits. All diagnostic programs shall be run to verify the proper operation of all digital equipment.

C. Final control elements and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits.

D. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses for final control elements. Simulated input data signals may be used subject to prior written approval by the Engineer.

E. Each control strategy shall be tested to verify the proper operation of all required functions. The control system start-up and test activities shall include procedures for tuning all control loops incorporating PID control modules, and for adjusting and testing all control loops as required to verify specified performance.

F. The control system start-up and test activities shall include running tests to prove that the Instrumentation, Control and Information System is capable of continuously, safely and reliably regulating processes, as required by the Contract, under service conditions that simulate, to the greatest extent possible, normal plant operating ranges and environmental conditions.

G. A witnessed functional acceptance test shall be performed to demonstrate satisfactory performance of individual monitoring and control loops and control strategies. At least one test shall be performed to verify that the control and instrumentation system is capable of simultaneously implementing all specified operations.

H. Each loop and control strategy test shall be witnessed and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

1.08 FACILITY STARTUP COORDINATION

A. Facility start-up shall comply with requirements specified in the Contract Documents and those requirements specified herein. Facility start-up shall commence after all previously described start-up and test activities have been successfully completed and shall demonstrate that the Instrumentation, Control and Information System can meet all Contract requirements with equipment operating over full operating ranges under actual operating conditions.

B. The control system start-up period shall be coordinated with process startup activities and shall be extended as required until all plant processes are fully operational and to satisfy the Engineer that all control system Contract requirements have been fulfilled in accordance with the Contract Documents.

C. The instrumentation subcontractor's personnel shall be resident at the facility to provide both full time (eight hours/day, five days/week) and 24 hours on call (seven days/week) support of operating and maintenance activities for the duration of the start-up period.

D. At least one qualified control systems technician shall be provided for control system startup and test activities (at least two when loop checkout is being performed).

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 17073

FINAL ACCEPTANCE TEST

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall perform the Final Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17070 – Control and Information System Testing, General

C. Section 17071 – Factory Acceptance Test

D. Section 17072 – Field Testing

1.03 AVAILABILITY DEMONSTRATION AND FINAL SYSTEM ACCEPTANCE

A. Upon completion of all control system startup activities and prior to final system acceptance, the Contractor shall demonstrate that the availability of the entire control system, including operation under conditions of digital equipment fail-over, initiated either automatically or manually, shall be not less than 99.8 percent during a 30-day availability test period. The Owner shall be given two (2) weeks notice of the starting date of the 30-day availability test.

B. For purposes of determining availability figures, downtime of each system or portions of each system resulting from the causes specified hereunder will not be considered system failures.

1. Downtime of any network-connected device that is automatically backed-up upon failure shall not be considered a system failure provided that the downtime of the failed component does not exceed 24 hours.

2. Downtime of a PLC that is not automatically backed-up shall be considered a system failure if the downtime of the failed controller exceeds one (1) hour.

3. Downtime of a portion of the system resulting from failure of any field sensor shall not be considered a system failure provided that the system operates as specified under this condition.

4. Downtime of the following devices shall not be considered a system failure provided the failed device is repaired within the specified time:

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a. Hard disc (one day)

b. Workstations (one day)

c. Communication interfaces (eight hours)

d. Printer (three days)

e. Process control system networks (eight hours)

f. Off-line (optical, etc.) storage units (one day)

g. UPS unit (one day)

5. Total shutdown of a single PLC resulting from a software fault shall be considered a system failure.

6. An erroneous command to the process that can be specifically related to a software fault shall be considered as one (1) hour of downtime.

7. The inoperability of any subsystem resulting from a software fault shall be considered a system failure.

8. The failure of the same component more than one time during the 30-day test shall be considered a system failure.

C. If the system fails the 30-day availability test, the 30-day test period shall be restarted after the failed component or software is repaired/replaced and full operation is restored. The system shall be demonstrated for the full 30-day period following the restart.

D. The Contractor shall submit an availability demonstration report that shall state that all system availability requirements have been met.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 17080

QUALITY ASSURANCE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. It is the intent of these Specifications and Drawings to secure high quality in all materials, equipment and workmanship in order to facilitate operations and maintenance of the facility. The Contractor shall provide equipment and services to meet this intent.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. All work shall be installed in accordance with the National Electric Code, National Electric Safety Code, OSHA, State, local and other applicable codes.

1.03 QUALITY ASSURANCE - GENERAL

A. All equipment and materials shall be new and the products of reputable recognized suppliers having adequate experience in the manufacture of these particular items.

B. For uniformity, only one manufacturer will be accepted for each type of product.

C. All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses that may occur during fabrication, transportation, and erection as well as during continuous or intermittent operation. They shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.

D. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, which shall be of sturdy and durable construction and be suitable for long, trouble-free service.

E. Electronic components shall be de-rated to assure dependability and long-term stability.

F. Printed circuit boards in field mounted equipment shall be suitable for the specified environmental conditions.

G. Alignment and adjustments shall be non-critical, stable with temperature changes or aging and accomplished with premium grade potentiometers.

H. Components of specially selected values shall not be inserted into standard electronic assemblies in order to meet the performance requirements of this specification.

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1.05 OPTIONAL EQUIPMENT

A. Optional or substituted equipment or both requiring changes in details or dimensions required to maintain all structural, mechanical, electrical, control, operating, maintenance or design features incorporated in these Specifications and Drawings shall be made at no additional cost to the Owner. In the event that the changes are necessary, calculations and drawings showing the proposed revisions shall be submitted for approval. The Contractor shall coordinate all changes with other affected trades and contracts and pay all additional charges incurred.

1.06 GUARANTEE

A. The instrumentation subcontractor through the Contractor shall install, maintain and guarantee the Instrumentation, Control and Information System as specified under the General Conditions and Division 1 of the Specifications. Maintenance personnel provided by the instrumentation subcontractor shall instruct the Owner's personnel in the operation, adjustment, calibration and repair of the equipment being serviced. All preventive and corrective activities shall be documented with service reports, which shall identify the equipment being serviced, state the condition of the equipment, describe all work performed and list materials used. A copy of all service reports shall be delivered to the Owner on the day the work is performed.

B. The instrumentation subcontractor shall provide the services of factory-trained service technician(s) at least twice during the guarantee period, for the purpose of performing preventive hardware maintenance.

C. Corrective hardware and software maintenance during the guarantee period shall be performed in accordance with the requirements of Division 1 and, in addition, shall meet the following requirements:

1. Corrective hardware maintenance shall be performed by factory-trained service technician(s) specifically trained to service the digital equipment provided. Technicians possessing suitable training and experience shall be provided to perform corrective maintenance on all other equipment. The hardware service technician(s) shall be available on-site within 24 working hours after notification by the Owner.

2. Corrective software maintenance shall be performed for software provided by the instrumentation subcontractor and incorporated into the system prior to the completion of system commissioning. Software service programmer(s) shall be available for consultation within four business hours and, if required, on-site within 16 business hours after notification by the Owner. Corrective software maintenance shall include the supply, installation and startup of all application software upgrades released during the guarantee period.

3. Corrective hardware and software maintenance performed during the guarantee period shall be performed at no cost to the Owner.

4. As used herein, the term "working hours" shall be defined as those of the treatment facility (seven days per week, 24 hours per day). The term "business hours" shall be defined as the hours between 8:00 a.m. and 5:00 p.m., local time, Monday through Friday; excluding holidays.

5. The guarantee period shall commence upon final acceptance of the completed treatment facility in accordance with the provisions of the Contract Documents.

D. The instrumentation subcontractor shall submit to the Owner a proposed maintenance agreement incorporating the following features:

1. Extension of preventive hardware maintenance services as described above for a period of up to five years from the expiration of the warranty period.

2. Provisions for corrective hardware and/or software maintenance work on a will-call basis for a period of up to five years from the expiration of the warranty period. Corrective maintenance work shall be performed by properly trained personnel as described above.

E. The proposed agreement shall include provisions for payment based upon an annual fee for preventive maintenance and cost plus expenses for corrective maintenance work. The portion dealing with corrective maintenance shall be written to include corrective maintenance caused by actions of the Owner during the warranty period and shall contain clauses for re-negotiation of contract prices based upon changes in recognized economic indicators published by the United States Department of Commerce.

1.07 SHIPPING HANDLING AND STORAGE

A. In addition to shipping, handling and storage requirements specified elsewhere in the Contract Documents, air conditioning/heating shall be provided for storage of all field instrumentation, panels, digital equipment and ancillary devices to maintain temperatures between 20 and 25 degrees C and relative humidity 40 to 60 percent without condensation. The air shall be filtered and free of corrosive contaminants and moisture.

1.08 FABRICATION

A. Fabrication of all equipment shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

B. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. The Contractor shall provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.

C. Equipment approval at the factory only allows the equipment to be shipped to the project site. The Contractor shall provide for the proper storage, installation and satisfactory start-up and operation of the equipment to the satisfaction of the equipment manufacturer, the instrumentation subcontractor, and the Engineer.

1.09 INSTALLATION

A. All instrumentation and control system installation work, whether new construction or modifications to existing equipment/panels/structures, shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

B. The instrumentation subcontractor shall assign a competent representative who shall provide full time coordination and supervision of all on-site instrumentation and control system construction work from commencement of construction through completion and final acceptance.

C. All labor shall be performed by qualified craftsmen in accordance with the standards of workmanship in their profession and shall have had a minimum of three years of documented experience on similar projects.

D. All equipment and materials shall fit properly in their installations. Any required work to correct improperly fit installations shall be performed at no additional expense to the Owner.

E. All work shall be performed in a neat and workmanlike manner. All hardware and instrumentation shall be installed in accordance with requirements specified herein, in accordance with industry best practices, in accordance with manufacturers' recommendations, and in a manner suitable for ease of operation, inspection, and maintenance. All wiring shall be neatly bundled, run in wireway, and terminated. All spare wiring shall be neatly coiled and clearly labeled at both ends for future use by the Owner. Any work not meeting these requirements shall be corrected at no expense to the Owner.

F. Sufficient common-mode and differential-mode noise rejection shall be provided to insure operation of the plant process control system to meet all specification requirements. General practice shall include:

1. Maintaining crossings between noisy wires and signal wires at right angles.

2. Maintaining separation between noisy wires and signal wires as wide as practical.

3. Grounding all signals, shields and power supplies at the process control unit or local control panel.

4. Providing passive filters on signals with time constant compatible with scan intervals and overvoltage protection.

5. Eliminating cable splices. All splices in instrumentation and control system signal and network cables shall be approved in advance by the Engineer.

6. Providing a floating output for transmitters that have their own power sources.

G. DC and AC power grounding shall be performed in accordance with the digital hardware manufacturer's recommendations as well as all applicable code requirements.

H. The case of each field instrument and control panel shall be grounded in compliance with the National Electric Code.

I. Power wires shall be separated from parallel-running signal wires by the following minimum spacing:

CIRCUIT VOLTAGE (VAC)	MINIMUM SPACING (IN.)
120	12
240	18
480	18
2000 and above	24

J. The Contractor shall provide all required cutting, drilling, inserts, supports, bolts, and anchors, and shall securely attach all equipment and materials to their supports. Embedded supports for equipment furnished under this Division shall be provided and installed as shown specified herein and shown on the Drawings.

K. Following acceptance of the factory tests by the Engineer, and in accordance with the construction schedule, the Contractor shall commence installation of the digital control system hardware. Digital system equipment items shall not be installed, however, until all architectural, mechanical, HVAC and electrical work has been completed in the equipment rooms, MCC's, control rooms and all structural and/or mechanical work has been completed within 50 feet of equipment locations.

L. Upon completion of the above construction work, the Contractor shall request an inspection of the above-named areas. The Engineer will issue a written approval to proceed with delivery and installation only after being satisfied that all work described above has been properly performed. Digital equipment shall remain at the factory site or storage prior to approval for delivery to the project site. Partial shipments may be required to meet construction schedule requirements.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 17100

CONTROL AND INFORMATION SYSTEM HARDWARE, GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The process control system is physically and functionally distributed between PLC equipped control panels, motor control panels, field panels, operator workstations and appurtenances.

B. Although manual control facilities shall be provided adjacent to each final control element or in local control panels, such facilities are for testing, maintenance and local monitoring purposes only and shall not be regarded as backup to the PLC-based control system.

C. PLCs may be categorized as either “process PLCs” that are provided by the instrumentation subcontractor or “equipment control PLCs” provided by equipment manufacturers for the operation of their equipment (blowers, centrifuges, chemical systems, filters, etc.). Unless otherwise specified, all PLCs provided under this Contract shall conform to the requirements specified in this Division.

D. Major plant control system digital equipment items are described in the Specifications and shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17120 – Programmable Logic Controllers

B. Section 17140 – Operator Workstations

C. Section 17180 – Process Control System Networks

1.03 DIGITAL HARDWARE CONFIGURATIONS

A. The digital hardware configuration shown on the Control System Architecture Drawing depicts overall system configuration requirements. System design shall be based upon this concept and shall provide an overall digital system availability of 99.8 percent under the conditions specified in Section 17073. Unless otherwise specified, designs that vary from this concept will be rejected.

B. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level. Run time and flow accumulations shall be performed at the PLC level. Except for minimal calculations related to report-specific functions such as minimum, maximum, average, etc., operator workstations shall not be used to perform calculation for the process control system. Operator workstations shall be fully independent devices, individually connected to the plant control system networks.

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C. No other exceptions will be considered.

PART 2 -- PRODUCTS

2.01 GENERAL SYSTEM HARDWARE REQUIREMENTS

A. Unless otherwise specified, all hardware shall be rated for industrial use, resistant to shock, vibration, electromagnetic interference, static discharge, and suitable for the environmental conditions described elsewhere in this Division. Commercial or office grade equipment shall not be accepted.

B. Unless otherwise specified, modular construction shall be employed to simplify maintenance and to provide for future hardware expansion. Plug-in, modular PCB's or modules shall be employed for easy removal to permit exposure of circuit wiring, components and test points. Extender boards shall be provided if necessary to permit PCB's to be completely exposed for testing purposes.

C. Keying schemes shall be used to prevent PCB misplacement.

D. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature.

2.02 DIGITAL SYSTEM FAILURE DETECTION AND FAIL-OVER REQUIREMENTS

A. No degradation in control system performance shall occur when the system is operating in a partial failure or an equipment fail-over mode. Likewise, no degradation of system performance shall occur while a backed up system component is undergoing preventive or corrective maintenance.

B. All devices connected to the plant control system network shall be self-checking and shall report their operational status to the operator workstations as either "normal" or "failed". A graphic display based on the system architecture drawing shall be furnished with the control and information system showing this information along with current communication status of each device.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17000, Part 3.

- END OF SECTION -

SECTION 17120

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all programmable logic controllers, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17060 – Signal Coordination Requirements

C. Section 17100 – Control and Information System Hardware - General

D. Section 17125 – Operator Interface Units

E. Section 17500 – Enclosures, General

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050 - Tools, Supplies, and Spare Parts. In addition, the following specific spare parts items shall be provided:

1. One of each type and size of module for PLC equipment furnished under this Contract.

2. One of each type and size of PLC and equipment power supply furnished under this Contract.

PART 2 -- PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLERS - GENERAL

A. The instrumentation subcontractor shall furnish programmable controllers (PLC's) as specified herein and as shown on the Drawings. PLC's shall be provided complete with backplane, power supply, I/O cards, special function cards, instructions, memory, input/output capacity, and appurtenances to provide all features and functions as described herein. No substitutions will be permitted.

B. All components of the PLC system shall be of the same manufacturer; who shall have fully tested units similar to those being furnished in an industrial environment with associated electrical noise. The PLC system shall have been tested to meet the requirements of NEMA Standard ICS 2-230 (Arc Test) and IEEE C37.90.1 (SWC). The processing unit

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shall perform the operations functionally described herein based on the program stored in memory and the status of the inputs and outputs.

C. Programmable controllers shall be designed to operate in an industrial environment. The PLC shall operate in an ambient temperature range of 0°-60°C and a relative humidity of 5-95 percent, non-condensing. The PLC shall operate on supply voltages of 90-132 VAC at 47-63 Hz or 24 VDC if provided with a battery backup system. An integral fuse shall be provided on the power supply for short circuit protection and shall be front panel accessible. Integral overcurrent and undervoltage protection shall be provided on the power supply.

D. Where applicable, the minimum PLC backplane size shall be 7 slots, not including power supply slots.

E. System configuration shall be as shown on the Control System Architecture Drawing. PLC types shall be designated on the Control System Architecture Drawing and correspond to the specifications herein. Only a single type of processor shall be supplied for all PLCs of a designated type. **Memory and processor shall be adequate for all control functions specified.** PLCs shall be as manufactured or equal to the following:

1. Allen-Bradley ControlLogix

2.02 PROCESSORS

A. The processor and its associated memory shall be enclosed in a modular enclosure. A multiple-position selector switch or equivalent shall be used to select processor operating mode. LED-type indicating lights shall be provided to indicate processor, memory, and battery status. Errors in memory shall be recognized and shall activate the memory error indicating lights. The PLC processor shall monitor the internal operation of the PLC for failure and provide an alarm output. Nonvolatile memory in the form of a manufacturer supplied industrial CompactFlash card or equivalent technology shall be required to maintain the entire current program and firmware of the controller in the event of power loss. The program shall be updated onto the flash memory each time a program change such as an online edit or tag value is changed. When nonvolatile memory (flash memory) is not available for certain controller models as offered by the PLC manufacturer, lithium batteries shall be used to maintain process RAM memory for at least one year in the event of power loss. The lithium battery unit shall be an externally mounted battery assembly with the highest available capacity. The PLC shall send an alarm to the plant control system if battery level is low.

B. The instruction set for the PLC shall conform to the requirements of IEC 61131-3. Each PLC shall have the capability to run all five of the standard IEC 61131-3 languages simultaneously. These five languages shall be:

1. Ladder Diagram
2. Structured Text
3. Instruction List
4. Function Block Diagram
5. Sequential Function Chart

C. Additional co-processors or modules may be necessary and shall be furnished as required to meet the functions specified herein and in Section 17950 – Functional Control Descriptions.

D. PLC processors shall be provided with substantial user program, data and logic memory to allow for future expansion of the overall system. The total memory used on each processor shall be less than 60% of available memory at project completion.

2.03 COMMUNICATIONS

A. In addition to a communications port for the control system network, communication ports shall be provided for any other devices required (i.e., operator interface unit) plus an additional communication port for connection to a notebook computer.

B. The PLC shall be able to support various types of fieldbus communication systems for data links to field instruments (where specified) in addition to connected equipment such as power monitors, VFDs, motor protection monitors, etc. As a minimum, Profibus DP, Foundation Fieldbus, Modbus RTU Master and Slave, TCP/IP Ethernet shall be supported. The Contractor shall coordinate the efforts of the necessary parties (instrumentation subcontractor and equipment suppliers) to accomplish the required device and data table addressing between each PLC and the associated connected equipment.

C. Additional communication modules or protocol gateways may be required to support specific communication protocols required under this Contract and shall be supplied at no extra cost to the Owner.

2.04 INPUT/OUTPUT SUBSYSTEMS

A. Input/output hardware shall be plug-in modules in associated I/O backplane/chassis or DIN-rail mounting assemblies. Each unit shall handle the required number of process inputs and outputs plus a minimum of 10 percent active pre-wired spares for each I/O type furnished, plus a minimum of 20 percent spare I/O module space for the addition of future circuit cards or modules.

B. Discrete inputs shall be 24 VDC or 120 VAC signals (integral to the PLC) from dry field contacts. Discrete outputs shall be 24 VDC or 120 VAC outputs sourced from the PLC, or dry relay contacts (2A minimum) as required. Refer to Section 17060 – Signal Coordination Requirements for further details of discrete signal type and voltage requirements. The PLC shall provide momentary and latched outputs as required to interface with motor controls and external devices. Interposing relays shall be provided where required to interface with field equipment. Interposing relays shall be as specified in Section 17550. Electrical isolation shall be provided where required. Maximum density for discrete I/O modules shall be 32 per input module and 16 per output module.

C. Analog input circuits shall be isolated, minimum 16-bit resolution type. Analog input hardware shall be provided as required for all types of analog inputs being transmitted to the PLC. In general, analog input modules shall be capable of receiving 4-20 mA signals. Where required, RTD input modules shall have a minimum resolution of 0.15°C and be capable of accepting signals from 100-ohm Platinum RTD's. Analog outputs shall be coordinated with the receivers but shall generally be isolated 24 VDC 4-20 mA outputs

powered from the PLC. Each input/output circuit shall have optical isolation to protect the equipment against high voltage transients. Optical isolation shall be rated at not less than 1500 V RMS. Lightning/surge protection shall be provided as specified in Section 17560 - Surge Protection Devices. Maximum density for analog I/O modules shall be 8 per module.

D. Input/output modules shall be configured for ease of wiring and maintenance. The modules shall be connected to wiring arms that can be disconnected to permit removal of a module without disturbing field wiring. Covers shall be provided to prevent operator personnel from inadvertently touching the terminals. The process interface modules shall be provided with screw-type terminal blocks with barriers between adjacent terminals for connection of field inputs. Terminals shall be suitable for accepting up to and including No. 14 AWG wire. All DC output circuits to the field shall include fuses, either integral or at the terminal strip. Output failure mode shall be selectable so that upon station or communication system failure all outputs shall be placed either in the non-conducting mode, or remain as were prior to failure. Light-emitting diodes shall be provided for status indication for each input and output point.

E. External power supplies shall be provided with the PLC as required to meet specified installed I/O power requirements plus spares. Power supplies shall be modular units, shall be fully redundant and shall alarm the PLC upon failure. Power supplies shall have a line regulation of 0.05% and meet the environmental and power requirements specified herein for the PLC.

2.05 REMOTE I/O SUBSYSTEMS

A. Remote I/O shall be provided as designated on the Control System Architecture Drawing. Remote I/O shall be either PLC backplane type I/O or field modules as manufactured by the PLC manufacturer. Field modules shall meet the requirements of Subsection 2.04, Input/Output Subsystems. Remote I/O processor or communication modules shall be modular and individually replaceable.

B. Remote I/O shall communicate with the PLC using the PLC manufacturer's standard protocol or an open standard network such as DeviceNet, Ethernet IP, ProfiNet, Foundation Fieldbus, Modbus TCP/IP, or equal.

2.06 INPUT/OUTPUT CIRCUIT ARRANGEMENT

A. Signal and control circuitry to individual input/output boards shall be arranged such that board failure shall not disable more than one half of the control loops within any group of controlled equipment (e.g., one pump out of a group of three pumps, two pumps out of four, etc.). Where possible, individual control loops and equipment shall be assigned to individual boards such that failure of the board will disable only one loop or piece of equipment.

2.07 PROGRAMMING SOFTWARE

A. The PLC programming and configuration software shall be the manufacturer's latest, full-featured version, Windows-based, and shall be fully compliant with IEC 61131-3 standards. The software package shall consist of all programming, configuration, and documentation software needed to place the control and information system in satisfactory

operation. The software shall allow on-line and off-line program development and documentation. PLC programming software shall include documentation on optical media.

B. A minimum of one copy of the PLC programming software shall be purchased by the instrumentation subcontractor and registered to the Owner.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. PLC programming shall be furnished to perform all functions described in Section 17950 – Functional Control Descriptions, including global functions. In addition, PLCs shall be programmed to provide additional functions described in other sections of this Division.

B. PLC programming shall make use of the various IEC languages as appropriate to the specific task and shall be performed in a modular style making extensive use of program blocks (subroutines) and program variables to be passed to the program blocks for specific equipment. It is the intent of this requirement to allow for enhanced readability and ease of modification of the program code through the elimination of multiple instances of repeated code for the same function in a “hard-coded” style.

C. Extensive comments shall be placed in the program code to describe the functions of all elements of the program code. PLC code that does not contain comments shall be rejected.

D. Refer to Section 17000, Part 3 for additional requirements.

3.02 REQUIREMENTS FOR MANUFACTURER-SUPPLIED PLCs

A. PLCs that are supplied for equipment local control panels by individual equipment manufacturers or suppliers shall, where so indicated on the Control System Architecture Drawing, be integrated into the plant control system. The manufacturer-supplied PLC shall be furnished, installed and programmed by the manufacturer. The PLC shall continuously monitor and control the associated system and at the same time shall provide all the required alarms, indications of system parameters, equipment status, etc. to the main control system at the plant.

B. Where required as described above, each manufacturer-supplied PLC shall be connected to the Ethernet process control network for access from the plant control system HMI servers, as specified in Section 17180, and shall contain a fiber optic Ethernet switch identical to those provided for the rest of the network-connected PLCs.

C. Each equipment manufacturer shall provide all monitoring and control data to be transferred between the PLC and the plant control system in contiguous blocks of PLC registers to facilitate block read and write commands for efficient scanning by the control system SCADA servers. These contiguous registers shall be arranged in a single data transfer area, which shall be divided into eight distinct areas with an emphasis on flexibility and future expansion. The distinct areas shall be arranged by data type (analog or discrete), transfer direction (server to PLC or PLC to server), and, where applicable,

implementation schedule (current or future). Where required, peer-to-peer communication between PLCs shall likewise be accomplished using separate blocks of contiguous registers. Where individual equipment PLCs are not required to be connected to the plant control system via the data highway network, they shall provide the individual hardwired signals as specified in the Contract Documents. Data and commands for connection to the control system are described in the Drawings, the Input/Output Schedule, the individual equipment specification sections, and in Section 17950 – Functional Control Descriptions.

D. The operator interface for control of each individual system shall be performed by local operator interface units as specified in Section 17125 or individual pilot devices on the equipment local control panel, as specified in the associated equipment specification section. Additional operator interface functions shall be provided through the plant control system as specified in the respective equipment specifications and in Section 17950.

E. Where operator interface and control functions are required to be provided through the plant control system, the individual system supplier shall be responsible for coordination with the instrumentation subcontractor to provide a complete and working equipment control system. The individual equipment supplier shall also be responsible for limiting the access of the plant control system to the equipment PLC code so as to prevent malfunctions of the equipment and any failure to continuously perform its intended functions. The equipment supplier shall be responsible for ensuring that no actions by the plant control system can damage or otherwise adversely affect the operation of the associated equipment or the safety of personnel working on or near that equipment. The equipment supplier shall also provide direction in the configuration of the SCADA software's security system by the instrumentation subcontractor to limit access to the control functions of the equipment control system to authorized personnel only. The equipment supplier shall coordinate testing of the completed system with the instrumentation subcontractor, which shall conform to the requirements of Section 17072 – Field Testing.

F. The Contractor, equipment supplier and instrumentation subcontractor shall coordinate testing and startup of the equipment provided by the equipment supplier with the plant control system, including but not limited to the following tasks:

1. Provide assistance with control system testing of inputs, outputs, and control strategies as needed.

2. Provide support or interface work necessary to perform physical checkout and field testing to the final field devices. The schedule may require the instrumentation subcontractor and equipment manufacturer personnel to perform loop checks simultaneously, as directed by the Engineer.

3. Coordinate and assist as needed to maintain I/O connectivity throughout the system.

4. Ensure personnel safety while equipment is exercised via the plant control system.

5. Ensure that process, instrumentation, and control equipment are not damaged while equipment is exercised via the plant control system.

6. Provide temporary modifications to field devices and their terminations, if needed.

7. Providing labor and supervision, which may include, but is not limited to, the following: electricians, instrument technicians, manufacturer's representatives, and individual(s) knowledgeable about process startup and operation.

8. Operation of process equipment for verification of each plant control system input and output.

- END OF SECTION -

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SECTION 17125

OPERATOR INTERFACE UNITS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all operator interface units, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Digital System Hardware Configuration

C. Section 17120 – Programmable Logic Controllers

PART 2 -- PRODUCTS

2.01 OPERATOR INTERFACE UNIT

A. An Operator Interface Unit (OIU) shall be provided to view and change PLC monitoring and control parameters and to display alarm messages using a graphical user interface. The OIU shall provide the following features as a minimum.

1. Minimum of 6.5 inch diagonal display
2. 18-bit color TFT LCD 640 X 480 VGA display
3. Backlit analog resistive touch screen interface w/ 1 million press actuation rating
4. Backlight w/ min. 50,000 hr life to half brightness
5. Minimum of 512 MB internal storage
6. Minimum of 512 MB RAM application memory
7. Minimum of 80 MB nonvolatile user memory
8. Windows CE Operating System
9. Battery-backed real-time clock
10. Secure Digital (SD) card slot w/ min. 2 GB card
11. One USB 2.0 high-speed Type A host port; one USB 1.0 high-speed Type B device port
12. One 10/100Base-T Auto MDI/MDI-X Ethernet port
13. Windows-based configuration software complete with download cable
14. Operating Voltage: 120 VAC or 24 VDC (internal or via independent power supply)
15. Enclosure Rating: NEMA 12/4X to match the associated PLC cabinet rating
16. Environment: 0-55°C, 5-95% relative humidity, non-condensing

B. The operator interface unit shall be Allen-Bradley PanelView Plus 7 Standard 700, or equal.

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PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. The OIU shall be configured to display all PLC I/O, setpoints, and parameters. All equipment failures shall be alarmed. PLC I/O values and operator-entered setpoints shall be displayed with associated units and service descriptions. Menus shall be provided to navigate between screens of different equipment items. Displays shall be arranged in a hierarchical structure with displays for specific equipment items grouped together. Additional functionality shall be as specified elsewhere in this Division.

B. All necessary configuration and programming software shall be provided on optical media and turned over to the Owner.

C. Unless otherwise noted, each OIU shall be mounted between 48 and 60 inches above the floor or work platform.

D. Refer to Section 17000 for additional requirements.

- END OF SECTION -

SECTION 17180

PROCESS CONTROL SYSTEM NETWORKS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation IEEE 802.3 Ethernet local area network(s) for communications among plant devices.

B. Local area network shall be provided with all spare parts, accessories, and appurtenances as herein specified.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17120 – Programmable Logic Controllers

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. The following specific spare parts items shall be provided:

1. A termination tool kit shall be provided containing all required tools and consumables for up to 25 connections of each connection type furnished. Termination kit shall be as manufactured by Black Box, Corning Cable Systems, Optical Cable Corporation, or equal.

2. One spare switch of each type furnished under this Contract.

PART 2 -- PRODUCTS

2.01 LOCAL AREA NETWORK (LAN)

A. An IEEE 802.3 Ethernet local area network shall be used for communications between plant devices.

B. Network wiring shall be unshielded, twisted-pair copper cables for connections within buildings. Fiber optic media shall be used for all inter-device communication links extended outside of a building, unless specifically noted. Cables shall be as specified herein.

C. The Contractor may provide a network configuration different from that shown in the Contract Drawings with written approval of the Engineer, but the Contractor shall coordinate with all affected trades and pay for all additional charges incurred.

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D. The Contractor shall supply all hardware, cables, connectors, and software to implement a network as specified herein and shown on drawings.

2.02 INDUSTRIAL ETHERNET NETWORK SWITCHES

A. Except where specifically allowed on the Control System Architecture Drawing, industrial Ethernet network switches shall be provided for each device connected to the process control system network. The switches shall create switched Ethernet networks that conform to the IEEE 802.3 and 802.3u standards using copper wires or optical fibers in a bus, tree or ring network topology as shown on the Drawings. Ethernet network switches shall be modular, rack mounted, or standard DIN-rail mounted within the PLC cabinet or in an adjacent communication cabinet, as shown on the Drawings.

B. Ethernet network switches shall support ring, bus, tree, or point-to-point network topologies. On-line signal monitoring shall be provided to detect and locate impending faults. Ethernet network switches shall be replaceable on-line without disrupting the network. The Ethernet network switches shall be integrated into the in-plant Ethernet network to form a redundant ring network with self-healing communication recovery. Switches shall support the non-proprietary Media Redundancy Protocol (MRP) and Rapid Spanning Tree Protocol (RSTP) in addition to the switch manufacturer's standard redundant ring network protocol, all of which shall provide self-healing communication recovery.

C. Ethernet network switches shall meet the following minimum performance requirements:

Functions:	Modular managed switch with store and forward switching mode, 10 Mbps Ethernet, or 100 Mbps Fast-Ethernet, or gigabit Ethernet support, multi-address capability, auto-crossing, auto-negotiation, auto-polarity. Port speed and duplex auto-negotiation shall be configurable. Each network switch shall manage up to eight (8) ports possible via integrated media modules specified below.
Management:	Simple Network Management Protocol (SNMP) (v1/v2/v3) and Common Industrial Protocol (CIP) support; IGMP filtering and snooping.
Power Requirements:	Redundant 24 VDC power supply
Operating Temperature:	0° - 60°C
Relative Humidity:	10 - 95%
Network Size:	Up to 50 nodes in ring structure

Port Type & Quantity: (at each PLC location)

- MAs required; minimum of four eight (48) 10/100Base-TX, twisted pair cable, RJ-45 sockets, 0-100 meters LAN segment
- Two (2) 100/1000Base-FX, multimode fiber optic cables (62.5/125 µm), LC, ST or SC sockets, 0-5000 meters LAN segment

Link Budget: 8 dB @ 1300 nm; 10 dB @ 850 nm

Wavelength: 850 or 1300 nm

D. Acceptable industrial Ethernet network switches shall be as manufactured by Cisco Systems, Hirschmann, Phoenix Contact, Weidmuller, or equal.

2.03 OFFICE-GRADE ETHERNET NETWORK SWITCHES

A. Where specifically called out on the Drawings and where located in a suitable office-type environment (e.g., administration areas), office-grade Ethernet switches shall be provided for connectivity to the process control system network.

B. Office-grade Ethernet switches shall be rack-mounted as shown on the Drawings and shall meet the following specifications:

Functions/Protocol: Same as industrial switches

Power Requirements: Redundant 120 VAC power supply

Operating Temperature: 0° - 40°C

Relative Humidity: 10 - 95%

Port Type & Quantity: (at each location)

- Minimum of twelve (12) 10/100Base-TX, twisted pair cable, RJ-45 sockets, 0-100 meters LAN segment
- Two (2) 100/1000Base-FX, multimode fiber optic uplinks (62.5/125 µm), LC, ST or SC sockets, 0-500 meters LAN segment

C. Office-grade Ethernet switches shall be Catalyst by Cisco Systems, or equal.

2.04 FIBER OPTIC MEDIA CONVERTERS

A. Fiber optic media converters shall be provided to transform the specific PLC network communications protocol into an optical signal suitable for transmission over the fiber optic cable specified herein. Fiber optic media converters shall be modular, rack mounted, or mounted within the PLC rack.

B. Fiber optic media converters shall meet the following minimum performance requirements:

1.	Input Power:	110/220 VAC or 24 VDC (as required) for stand-alone panel-mounted modules or +5 VDC for PLC rack-mounted modules
2.	Operating Temperature:	0° - 60°C
3.	Node-to-Node Distance:	6500 feet
4.	Wavelength:	850 or 1300 nanometers
5.	Connector Type:	SC, LC, or ST

C. The PLC manufacturer's standard, PLC rack-mounted fiber optic transceiver may also be used, subject to approval by the Engineer.

D. Port speed and duplex auto-negotiation shall be configurable.

E. Acceptable fiber optic media converters shall be as manufactured by Black Box, Phoenix Contact or equal.

2.05 UNSHIELDED TWISTED PAIR CABLE

A. Unshielded twisted pair cable for drops within buildings shall consist of 4 pair of 24 AWG copper conductors in a flame-retardant jacket. Cable shall be plenum rated (UL 910) and meet EIA/TIA-568 Category 6 specifications. Unshielded twisted pair cable shall be Hyper Grade Extended Distance cable as manufactured by Berk-Tek, Belden equivalent, or equal. Connectors shall be modular RJ-45 plug.

2.06 FIBER OPTIC CABLE

A. Fiber optic cable shall conform to the following specifications:

1.	Fiber Type:	Graded Index (GI) Multimode
2.	Fiber/Cladding Diameter:	62.5/125 microns
3.	No. Fibers:	12, Color-coded
4.	Cable Construction:	Loose Tube w/ Ripcords
5.	Filling:	Water Swellable Dry Block
6.	Armored:	No
7.	Central Member:	Dielectric (Kevlar)
8.	Rating:	Gigabit Ethernet
9.	Bandwidth:	200/500 MHz-km at 850/1300 nm
10.	Maximum Attenuation:	3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm
11.	Application Type:	Direct-burial/Conduit/Aerial
12.	Sheath:	UV Resistant
13.	Max. Tensile Load:	600 lb (2700 N) installation;

		200 lb (890 N) long term
14.	Minimum Bend Radius:	7 in (17.4 cm) under maximum tensile load; 4.6 in (11.6 cm) unloaded (installed)
15.	Operating Temperature:	-40 to 70 degrees C
16.	Operating Relative Humidity:	0-100%

B. Fiber optic cable shall be ALTOS All Dielectric Loose Tube Optical Cable as manufactured by Corning Cable Systems, the Extended Performance Fiber Optic Cable Series as manufactured by Phoenix Digital, Inc., Belden equivalent, equivalent system by Optical Cable Corporation, or equal.

C. Upon entering a cabinet, panel or console, loose tube fiber optic cable shall be broken out using fan-out kits and terminated in a fiber optic patch panel. All individual fibers shall be terminated and all connections shall be tested. Tight buffered cable shall then be routed to the individual destinations as needed (or loose tube cable for runs to other buildings). Cabinet-mounted patch panels shall be Cabinet-Mounted Interconnect Center (C-MIC) as manufactured by Corning Cable Systems, equivalent by Black Box, Inc., Optical Cable Corporation, or equal.

D. Where cable is required to be routed to numerous, separate destinations within a building, loose tube cable shall be broken out immediately upon entering the building, all individual fibers terminated in a patch panel, and tight buffered, plenum rated cable shall be routed to the individual destinations. Building patch panels shall be Wall-Mountable Interconnect Center (WIC) or Premises Interconnect Center (PIC) as manufactured by Corning Cable Systems, equivalent by Black Box, Inc., Optical Cable Corporation, or equal.

E. Fiber optic cable for installation within buildings shall comply with all applicable fire and building safety codes for such applications.

F. Fiber optic cable shall utilize mechanically spliced, field installable, SC, LC, or ST compatible connectors. Connections shall have a typical loss of 0.35 dB or better and shall provide stable optical performance after numerous rematings. Connections shall utilize physical contact terminations utilizing UV or heat cured adhesive. Where applicable, field terminations shall use a simple procedure requiring minimal training.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. The destination of all network data cables (both copper and fiber) leaving an enclosure, patch panel, or building shall be labeled at each end using industry-standard wire markers.

B. Refer to Section 17000, Part 3 of the Specifications for additional requirements.

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SECTION 17500

ENCLOSURES, GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the control enclosures, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

B. Control enclosures shall be assembled, wired, and tested in the instrumentation subcontractor's own facilities, unless specified otherwise. All components and all necessary accessories such as power supplies, conditioning equipment, mounting hardware, signal input and output terminal blocks, and plug strips that may be required to complete the system shall be provided.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17510 – Cabinets and Panels

D. Section 17520 – Field Panels

E. Section 17550 – Panel Instruments and Accessories

F. Section 17560 – Surge Protection Devices

G. Section 17600 – Unpowered Instruments, General

H. Section 17700 – Powered Instruments, General

I. Section 17800 – Analytical Instruments, General

J. Refer to Division 16 for additional requirements for cable, circuit breakers, disconnect switches, etc.

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1.03 GENERAL INFORMATION AND DESCRIPTION

A. The cabinet itself and all interior and exterior equipment shall be identified with nameplates. The equipment shall be mounted such that service can occur without removal of other equipment. Face mounted equipment shall be flush or semi-flush mounted with flat black escutcheons. All equipment shall be accessible such that adjustments can be made while the equipment is in service and operating. All enclosures shall fit within the allocated space as shown on the Drawings.

B. Either manufacturer-standard or custom cabinetry may be furnished subject to the requirements of the Contract Documents and favorable review by the Owner.

C. Due consideration shall be given to installation requirements for enclosures in new and existing structures. The Contractor shall examine plans and/or field inspect new and existing structures as required to determine installation requirements and shall coordinate the installation of all enclosures with the Owner and all affected contractors. The Contractor shall be responsible for all costs associated with installation of enclosures, including repair of damage to structures (incidental, accidental or unavoidable).

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050 - Tools, Supplies and Spare Parts. In addition, the spare parts items shall be provided as specified in the individual cabinet and panel specification sections.

PART 2 -- PRODUCTS

2.01 TERMINAL BLOCKS

A. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the cabinet subpanel. Terminals shall be of the screw down pressure plate type as manufactured by Phoenix Contact, Weidmuller, Wieland, Square D, or equal.

B. Power terminal blocks for both 120 VAC and 24 VDC power shall be single tier with a minimum rating of 600 volts, 30 amps.

C. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20 amps.

PART 3 -- EXECUTION

3.01 FABRICATION

A. Enclosures shall provide mounting for power supplies, control equipment, input/output subsystems, panel-mounted equipment and appurtenances. Ample space shall be provided between equipment to facilitate servicing and cooling.

B. Enclosures shall be sized to adequately dissipate heat generated by equipment mounted inside the panel. If required, one or more of the following shall be provided to facilitate cooling:

1. Louvered openings near the bottom and top (NEMA 12 cabinets only).

2. Thermostatically controlled, low noise internal air blowers (initial setpoint 75°F) to circulate air within the enclosure, maintaining a uniform internal temperature.

3. Thermostatically controlled, low-noise cooling fans to circulate outside air into the enclosure, exhausting through louvers near the top of the cabinet (NEMA 12 cabinets only). Air velocities through the enclosure shall be minimized to assure quiet operation.

4. All openings in cabinets and panels shall be fitted with dust filters.

C. Enclosures shall be constructed so that no screws or bolt heads are visible when viewed from the front. Punch cutouts for instruments and other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.

D. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature. This thermostat shall be independent and separate from the thermostat used to control the temperature in the enclosure described above. Enclosure interior temperature alarm shall be displayed on the HMI.

E. Intrusion alarm switches shall be provided on all enclosures containing digital hardware and shall generate an alarm to the nearest PLC when any enclosure door is opened.

F. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for field incoming conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system will be acceptable.

G. Wiring within cabinets, panels, and consoles shall be installed neatly and shall comply with accepted standard instrumentation and electrical practices. Power, control and signal wiring shall comply with Division 16 of the Specifications, except that the minimum wire size for discrete signal wiring may be 16 AWG, and for analog wiring may be 18 AWG. For each pair of parallel terminal blocks, the field wiring shall be between the blocks.

H. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. Where applicable, terminal strips for different voltages of discrete signal wiring shall also be separated. Terminal strips shall be labeled as to voltage and function.

I. All wiring shall be bundled and run open or enclosed in vented plastic wireway as required. Wireways shall be oversized by a minimum of 10%; overfilled wireways shall not be acceptable. All conductors run open shall be bundled and bound at regular intervals, not exceeding 12 inches, with nylon cable ties. Care shall be taken to separate electronic signal, discrete signal, and power wiring.

J. Spare field wiring shall be bundled, tied, and labeled as specified above, and shall be neatly coiled in the bottom of the cabinet.

K. All installed spare I/O hardware shall be wired along with live I/O wiring to the field wiring terminal blocks within the cabinet. Where space for spare I/O modules has been provided with the PLC backplane or DIN-rail mounting system, corresponding space for wiring, surge protection, and terminations shall be furnished within the cabinet.

L. A copper ground bus shall be installed in each cabinet, and shall be connected to the building power ground.

M. Interior panel wiring shall be tagged at all terminations with machine-printed self-laminating labels. Labeling system shall be Brady TLS 2200 Printer with TLS 2200®/TLS PC Link™ labels, or equivalent system by Seton or Panduit. The wire numbering system and identification tags shall be as specified in Section 16123 - Building Wire and Cable. Field wiring terminating in panels shall be labeled in accordance with the requirements of Section 16123. Where applicable, the wire number shall be the ID number listed in the input/output schedules.

N. Wires shall be color coded as follows:

Equipment Ground - GREEN

120 VAC Power - BLACK
120 VAC Power Neutral - WHITE

120 VAC Control (Internally Powered) - RED
120 VAC Control (Externally Powered) - YELLOW

24 VAC Control - ORANGE

DC Power (+) - RED
DC Power (-) - BLACK
DC Control - BLUE

Analog Signal – BLACK/WHITE or BLACK/RED

O. Enclosures shall be provided with a main circuit breaker and a circuit breaker on each individual branch circuit distributed from the panel. Main breaker and branch breaker sizes shall be coordinated such that an overload in a branch circuit will trip only the branch breaker but not the main breaker.

P. Enclosures with any dimension larger than 36 inches shall be provided with 120-volt duplex receptacles for service equipment and LED service lights. Power to these devices shall be independent from the PLC power supply and its associated uninterruptible power system.

Q. Where applicable, enclosures shall be furnished with red laminated plastic warning signs in each section. The sign shall be inscribed "WARNING - This Device Is Connected to Multiple Sources of Power". Letters in the word "WARNING" shall be 0.75 inch high, white.

R. The interconnection between equipment and panel shall be by means of flexible cables provided to permit withdrawal of the equipment from the cabinet without disconnecting the plugs.

3.02 PAINTING/FINISHING

A. All steel enclosures shall be free from dirt, grease, and burrs and shall be treated with a phosphatizing metal conditioner before painting. All surfaces shall be filled, sanded, and finish coated by spraying a 1-2 mil epoxy prime coat and smooth, level, high grade textured finish between flat and semi-gloss shine. The colors shall be selected by the Owner from a minimum of six color samples provided. Refer to Division 9 for additional requirements.

B. Materials and techniques shall be of types specifically designed to produce a finish of superior quality with respect to adherence, as well as impact and corrosion resistance.

C. Panels fabricated from stainless steel shall not be painted.

D. Panels fabricated from non-metallic materials (e.g., FRP) shall be gel-coated and shall not be painted.

3.03 INSTALLATION

A. Refer to Section 17000 for additional requirements.

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SECTION 17510

CABINETS AND PANELS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the cabinets and panels, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17500 – Enclosures, General

PART 2 -- PRODUCTS

2.01 CABINETS AND PANELS

A. Cabinets and panels shall be formed or welded construction, reinforced with Unistrut, Powerstrut, or equal to facilitate mounting of internal components or equipment. Sufficient access plates and doors shall be provided to facilitate maintenance and testing of the cabinet's equipment. Doors shall be removable. Cabinets and panels with any dimension 36 inches or greater shall be provided with removable lifting lugs designed to facilitate safe moving and lifting of the panel during installation. All doors shall be fitted with common-keyed locks.

B. Cabinets and panels shall be minimum 14 USS gauge. Cabinets and panels with any dimension greater than 36 inches shall be 12 USS gauge.

C. Cabinets and panels located inside buildings, but located in areas other than climate controlled (heated and air conditioned) electrical or control rooms, shall be as a minimum 316 stainless steel NEMA 4X construction, or as specified or shown on the Drawings for hazardous area classification (Class, Division, Group), or submersible (NEMA 6) applications. Epoxy coated cast copper-free aluminum construction shall also be acceptable for NEMA 4, 6 and 7 applications. Cabinets located in storage/feed areas for chlorine or other applicable corrosive chemicals shall be of non-metallic construction, rated NEMA 4X, and fully compatible with the associated chemical.

D. Cabinets and panels within climate controlled (heated and air-conditioned) electrical or control rooms shall be all steel fully enclosed NEMA 12 units with gasketed doors.

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E. Cabinets and panels shall have doors on the front and shall be designed for front access. NEMA 12 cabinets shall be fitted with three-point door latches. Doors for NEMA 4X cabinets shall be all stainless steel with three-point latches. Door hardware on NEMA 4X cabinets located in chemical storage/feed areas shall be non-corrosive in that environment.

F. Panels and cabinets located outside fence-secured areas shall be fitted with padlockable latch kits.

G. All cabinets and panels shall be provided with drawing pockets for as-built panel drawings. One copy of the appropriate panel as-built drawings shall be furnished and left in the pocket of each panel.

H. Panels with any dimension greater than 36 inches that contain a programmable controller (PLC) shall be provided with a folding laptop programmer shelf on the inside of the door. When deployed, the laptop shelf shall not be greater than 48 inches above finished floor. Laptop shelf shall be fitted to door with factory applied weld-studs. Weld discoloration and enclosure penetrations will not be accepted.

I. Unless otherwise noted, panel-mounted control devices (OIUs, hand switches, etc.) requiring operator access shall be mounted between 48 and 60 inches above the floor or work platform.

J. Cabinets and panels shall be prefabricated cabinets and panels by Hoffman or Saginaw Control and Engineering (SCE). The Contractor may optionally provide cabinets that are custom-fabricated by the instrumentation subcontractor or by a reputable panel fabrication shop acceptable to the Engineer.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17500 for additional requirements.

- END OF SECTION -

SECTION 17560

SURGE PROTECTION DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install and place in satisfactory operation the surge protection devices (SPDs) as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17500 – Enclosures, General

1.03 GENERAL INFORMATION AND DESCRIPTION

A. All surge protectors of each type provided under this Contract shall be furnished by a single manufacturer.

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050 - Tools, Supplies and Spare Parts. In addition, the following specific spare parts items shall be provided:

1. Five of each type of surge protection device provided under this Contract.

PART 2 -- PRODUCTS

2.01 SURGE PROTECTION, GENERAL

A. All electrical and electronic elements shall be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical systems.

B. Manufacturer's Requirements: All surge protection devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Acceptable manufacturers shall be Phoenix Contact, Edco, Transtector, Weidmuller, or equal.

C. Surge protection device installations shall comply with UL 94, the National Electric Code (NEC), and all applicable local codes.

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D. Surge protection devices shall be installed as close to the equipment to be protected as practically possible.

E. Device Locations: As a minimum, provide surge protection devices at the following locations:

1. At any connections between ac power and electrical and electronic equipment, including panels, assemblies, and field mounted analog transmitters.

2. At both ends of all analog signal circuits that have any portion of the circuit extending outside of a protecting building.

3. At both ends of all copper-based communication cables which extend outside of a building, including at field instruments and the field side of analog valve position signals.

4. On all external telephone communication lines.

2.02 AC POWER PROTECTION

A. Surge protection device assemblies for connections to AC power supply circuits shall:

1. Be provided with two 3-terminal barrier terminal strips capable of accepting No. 12 AWG solids or stranded copper wire. One terminal strip shall be located on each end of the unit.

2. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements. The surge protection device shall be provided with provisions for mounting to interior of equipment racks, cabinets, or to the exterior of freestanding equipment.

3. Be constructed as multistage devices consisting of gas tube arrestors, high energy metal oxide varistors, or silicon avalanche suppression diodes. Assemblies shall automatically recover from surge events, and shall have status indication lights.

4. Comply with all requirements of UL 1449, latest edition.

5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

6. Have the following characteristics:

a. Maximum Continuous Operating Voltage: 150VAC
b. Maximum Operating Current: 20 amps
c. Ambient Temperature Range: -20 degrees C to +65 degrees C
d. Response Time: 5 nanoseconds

2.03 ANALOG SIGNAL CIRCUIT PROTECTION

A. Surge protection device assemblies for analog signal circuits shall:

1. Have four lead devices with DIN Rail mounting.

2. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

3. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.

4. Comply with all requirements of UL 497B.

5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

6. Limit line-to-line voltage to 40 volts on 24VDC circuits.

7. Have the following characteristics:

a. Maximum Continuous Operating Voltage: 28VDC
b. Ambient Temperature Range: -20 degrees C to +65 degrees C
c. Response Time (Line-to-Line): 5 ns

2.04 COMMUNICATION CIRCUIT PROTECTION

A. Surge protection devices for copper-based data communication circuits shall:

1. Be designed for the specific data communication media and protocol to be protected (i.e. telephone, serial, parallel, network, data highway, coax, twinaxial, twisted pair, RF, etc.).

2. Provide protection of equipment to within the equipment's surge withstand levels for applicable standard test wave forms of the following standards:

a. IEC 60-1 / DIN VDE 0432 part 2
b. CCITT K17 / DIN VDE 0845 part 2
c. IEEE C62.31

3. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

4. Provide automatic recovery.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17500 for additional requirements.

- END OF SECTION -

SECTION 17600

UNPOWERED INSTRUMENTS, GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The instrumentation subcontractor shall furnish, install, test and place in operation process instrumentation (flow elements, pressure switches, etc.) as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process equipment control panels with the process controls as shown on the Drawings and as specified. The Contractor may elect to install primary elements (flowmeters, etc.) on process lines provided that the instrumentation subcontractor provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The instrumentation subcontractor shall supervise installation of equipment provided under this Division where installation is provided by others.

C. Tapping and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instrumentation furnished under this Division are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17500 – Enclosures, General

C. Section 17698 – Instrumentation and Control System Accessories

D. Section 17700 – Powered Instruments, General

E. Section 17800 – Analytical Instruments, General

F. Unpowered instruments furnished with mechanical equipment shall be furnished, installed, tested and calibrated as specified elsewhere in the Contract Documents.

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. The instrumentation subcontractor shall provide spare parts as specified in individual instrument specification sections.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Unless otherwise specified, instruments shall be provided with enclosures to suit specified environmental conditions. Field-mounted devices shall be rugged and mounted on walls or pipe stanchions.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Equipment shall be located so that it is accessible for operation and maintenance. The instrumentation subcontractor shall examine the Drawings and Shop Drawings for various items of equipment in order to determine the best arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.

B. Field equipment shall be wall mounted or mounted on two-inch diameter pipe stands welded to a 10-inch square 1/2-inch thick base plate unless shown adjacent to a wall or otherwise noted. Materials of construction shall be aluminum or 316 stainless steel. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2-inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.

C. Embedded pipe supports and sleeves shall be Schedule 40, Type 316 stainless steel pipe, ASA B-36.19, with stainless steel blind flange for equipment mounting as shown on the Drawings.

D. Materials for miscellaneous mounting brackets and supports shall be 316 stainless steel construction.

E. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.

3.02 ADJUSTMENT AND CLEANING

A. The instrumentation subcontractor shall comply with the requirements of Division 1 of these Specifications and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative(s), reserves the right to witness any test, inspection, calibration or start-up activity. Acceptance by the Engineer of any plan, report or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.

B. The instrumentation subcontractor shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the Owner. The Contractor shall bear all costs and provide all personnel, equipment and materials necessary to implement all installation tests and inspection activities for equipment specified herein.

C. At least 60 days before the anticipated initiation of installation testing, the Contractor shall submit to the Engineer a detailed description, of the installation tests to be conducted to demonstrate the correct operation of the instrumentation and control system.

D. Field instrument calibration requirements shall conform to the following:

1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate each instrument supplied under this Contract to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration.

2. Each instrument shall be calibrated at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy’s as set forth by the National Institute for Standards and Technology (NIST).

3. The instrumentation subcontractor shall provide a written calibration sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made.

4. If doubt exists as to the correct method for calibrating or checking the calibration of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.

5. Upon completion of calibration, devices shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to overvoltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the Owner.

- END OF SECTION -

SECTION 17610

INSERT VENTURI FLOW TUBES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all insert venturi flow tubes, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17600 – Unpowered Instruments, General

C. Section 17760 – Pressure Indicating Transmitters

1.03 SUBMITTALS

A. The manufacturer shall provide data that substantiates head loss and accuracy for the flow tubes submitted, which shall include the following information:

1. Differential vs. flow curves.

2. Differential vs. flow data in tabular format.

3. Non-recoverable head loss data.

4. A certified dimensional drawing for each flow tube.

5. Specific equations for calculating airflow in scfm in the following format:

$$\text{Actual scfm} = \text{constant} \times \frac{(\text{Differential P})^{1/2} \times (\text{Operating Press.})^{1/2}}{(\text{Operating Temp.})^{1/2}} \quad \text{(Gas)}$$

B. Two copies of each of the following curves with plastic see-through type envelopes shall be furnished for each venturi tube by the manufacturer:

1. Certified differential pressure vs. flow at nominal static pressures.

2. For airflow, flow coefficient vs. pressure for above curves for a pressure range of ±3 psig from the nominal static pressures.

PART 2 -- PRODUCTS

2.01 INSERT VENTURI FLOW TUBES

A. The Contractor shall furnish the exact internal diameter of process piping to the instrumentation subcontractor for fabricating and calibrating flow tubes. The flow tube shall have pressure and temperature capabilities at least equal to the surrounding air piping. The Contractor shall coordinate end conditions for installation allowing for future removal of the tube by use of expansion fittings and flanges in the pipeline, as shown on the Drawings.

B. Insert flow tubes shall produce a differential pressure proportional to the square of flow. Inlet and outlet cones shall be made of polyester resin reinforced with 30 percent fiberglass by weight or stainless steel. The outlet cone angle shall be 10° or smaller for optimum energy recovery. The venturi meter shall have a cylindrical, precision-machined, 304 stainless steel throat section with a minimum length equal to 0.5 times its diameter. Center flange material shall be epoxy-coated carbon steel and shall match the pressure classification of the surrounding pipe. Flange gaskets shall be provided for sealing and shall be consistent with the rest of the gaskets used in the pipeline. Flow tube shall be designed for operation on air lines with temperature ranging from 0°F to 250°F.

C. Pressure taps shall be ½-inch or ¼-inch NPT as recommended by the manufacturer, constructed of 316L stainless steel. If the ¼-inch taps are furnished, appropriate fittings shall be provided to connect to the ½-inch process tubing. The low-pressure sensing tap shall be installed in the cylindrical throat section of the flow tube. The static or high-pressure sensing tap shall be located in the upstream spool piece of the flow tube. Location of the upstream tap shall be directed by the flow tube supplier. Corner-type high-pressure taps shall not be acceptable. Flushing/drain assemblies with stainless steel ball valves for isolation, together with fittings and appurtenances, shall be furnished on all high and low pressure taps.

D. Accuracy shall be + or - 0.50% of actual flow rate over the specified flow range. Permanent head loss shall not exceed 8% of the maximum differential pressure.

E. Sizing of all the insert flow tubes for airflow shall be based on a pressure range between 5.0 7.2 psig and a temperature range between 100 and 250°F.

F. The flow tubes shall be Model HVT-PS as manufactured by Primary Flow Signal, Inc., or equivalent by Badger Meter, BIF Products, or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All insert venturi meters and appurtenant work, including pressure taps, shall be installed in strict accordance with the manufacturer's printed instructions.

B. Refer to Section 17600, Part 3 for additional requirements.

- END OF SECTION -

SECTION 17650

PRESSURE GAUGES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure gauges, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17600 – Unpowered Instruments, General

C. Section 17698 – Instrumentation Accessories

PART 2 -- PRODUCTS

2.01 PRESSURE GAUGES

A. All gauges shall be designed in accordance with the ASME B40.1 entitled, "Gauges, Pressure, Indicating Dial Type - Elastic Element".

B. All gauges shall be direct reading type. Snubbers shall be provided on all gauges. Gauge full-scale pressure range shall be selected such that the maximum operating pressure shall not exceed the approximately 75% of the full-scale range.

C. Features

1. Mounting: ½" NPT, lower stem mount type
2. Accuracy: 0.5% full scale
3. Case: Solid front, black phenolic material
4. Dial: White background and black letters
5. Glass: Shatterproof
6. Blow-out protection: Back
7. Pressure element: stainless steel bourdon tube
8. Movement: Stainless steel, Teflon coated pinion gear and segment

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9. Gaskets: Buna-N

D. Liquid-filled or equivalent mechanically-damped gauges shall be used if the gauges are installed with pumps, or where gauges are subjected to vibrations or pulsation. Filling fluid shall be silicone unless oxidizing agents such as sodium hypochlorite are present, where halocarbon shall be used.

E. Gauge size shall be 2" for line sizes up to 3" and 4½" for line sizes of 4" or greater.

F. Diaphragm seals and isolating ring seals shall be furnished in accordance with the requirements specified under Section 17698 - Instrumentation and Control System Accessories.

G. The complete gauge assembly and appurtenances shall be fully assembled and tested prior to field mounting. A ½" isolation stainless steel ball valve shall be provided for each gauge assembly.

H. Pressure and vacuum gauges shall be Ashcroft Duragauge Model 1279, Ametek-U.S. Gauge Division, WIKA Instrument Corporation, or equal.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17600, Part 3.

- END OF SECTION –

SECTION 17698

INSTRUMENTATION AND CONTROL SYSTEM ACCESSORIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the instrumentation and control system accessories with all spare parts, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17600 – Unpowered Instruments, General

C. Section 17700 – Powered Instruments, General

D. Section 16902 – Electric Controls and Relays

PART 2 -- PRODUCTS

2.01 INSTRUMENTATION AND CONTROL SYSTEM ACCESSORIES

A. General: Accessories include various items of equipment that may be required in the system but are not scheduled. Accessories are shown on details, flow sheets or plans. Accessories are also called out in specifications for scheduled instruments and in the installation specifications. It is not intended, however, that each piece of hardware required will be specifically described herein. This subarticle shall be used as a guide to qualify requirements for miscellaneous hardware whether the specific item is described or not.

B. Process Tubing: Process tubing shall be 1/2 x 0.065-inch seamless, annealed, ASTM A-269 Type 316L stainless steel with Type 316 - 37 degrees stainless steel flared fittings or Swagelock or Parker-CPI flareless fittings.

C. Power, Control and Signal Cables: Power, control and signal wiring shall be provided under Division 16 of the Specifications.

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D. Chemical Diaphragm Seals: Diaphragm seals shall be provided for isolation of pressure gauges, switches and transmitters attached to systems containing chemical solutions or corrosive fluids. As a minimum, seals shall be of all 316 stainless steel construction. In general, diaphragms shall be 316L stainless steel for operating pressures at or above 15 psi and elastomers for operating pressures below 15 psi. However, all components shall be non-reactive with the process fluid in all cases. Refer to the Instrument Schedules for specific materials requirements. Seal shall have fill connection, 1/4-inch NPT valved flush port and capable of disassembly without loss of filler fluid. Where specified, diaphragm seals shall comply with the above requirements and shall be provided with 316 SS factory filled capillaries. Seals shall be Helicoid Type 100 HA, Mansfield & Green, Ashcroft, or equal.

E. Isolating Ring Seals: For solids bearing fluids, line pressure shall be sensed by a flexible cylinder lining and transmitted via a captive sensing liquid to the associated pressure sensing instrument(s).

1. Full Line Size Isolating Ring Seals - For all grit/sludge/slurry/scum applications or wherever the associated pressure instrument is used for control purposes, the sensor body shall be full line size wafer design. Except where noted on the Drawings and/or Instrument Schedule, full line size ring seals will not be required for return activated sludge (RAS) lines, but will have tapped ring seals as specified in Item 2, below. Full line size isolating ring seals shall have 316 stainless steel housing and assembly flanges and Buna N flexible cylinder lining for in-line mounting. The wafer shall have through bolt holes or centerline gauge for positive alignment with the associated flanged piping. The captive liquid chamber and associated instrument(s) shall be furnished with threaded drain tap and plug. Isolating ring seals shall be RED Valve Series 40, Ronningen-Petter Iso-Ring, Moyno RKL Series W, Onyx Isolator Ring, or equal.

2. Tapped Isolating Ring Seals - For all other solids bearing fluids, pressure shall be sensed via a minimum 1/2" diameter spool-type isolating ring seal mounted on a 1/2" pipe nipple at 90° from the process piping. An isolation ball valve shall be provided between the process piping and the ring seal, and a cleanout ball valve shall be provided between the ring seal and the atmosphere. The pressure instrument shall be back or side mounted to the ring seal such that the gauge or readout may be viewed normally. Tapped isolating ring seals for solids service shall be Red Valve Series 42/742, Ronningen-Petter Iso-Spool, Onyx Isolator Ring, or equal.

F. Filling Medium: The filling medium between instruments, isolating ring seals and diaphragm seals shall be a liquid suitable for operation in an ambient temperature ranging from -10°F to +150°F. Filling medium shall be silicone unless oxidizing agents such as sodium hypochlorite are present, where halocarbon shall be used.

G. Isolation Valves: Isolation valves shall be 1/2 - inch diameter ball valves with 316 stainless steel body, 316 stainless steel ball, except that materials of construction shall be suitable for the associated process fluid where applicable (i.e., chemical service).

H. Sirens: Sirens shall be UL Listed, heavy duty, AC motor driven, weatherproof type capable of producing a minimum of 111 dBA at 10 feet. Power supply shall be 120 VAC, 60 hertz. Siren shall be McMaster-Carr Model 6392T11, Federal Signal Corporation equivalent, Edwards Signaling Company equivalent, or equal.

I. Strobe Lights: Strobe lights shall be high profile with Type 304 stainless steel base. Light is rated NEMA 4. Light shall have an outer dome to provide extra lens protection. Lens color shall be as indicated on the Drawings. Surface mount hardware shall be included. Power supply shall be 120 VAC, 60 hertz. Strobe light shall be McMaster-Carr Model 5848T71, Federal Signal Corporation equivalent, Edwards Signaling Company equivalent, or equal.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17600, Part 3 of the specifications.

- END OF SECTION -

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SECTION 17700

POWERED INSTRUMENTS, GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The instrumentation subcontractor shall furnish, install, test and place in operation powered process instrumentation (flow elements, level transmitters, etc.) as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process equipment control panels with the process control system as shown on the Drawings and as specified. Powered instruments are those instruments that require power (120 VAC or 24 VDC loop power) to operate. The Contractor may elect to install primary elements (flowmeters, etc.) on process lines provided that the instrumentation subcontractor provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The instrumentation subcontractor shall supervise installation of equipment provided under this Division where installation is provided by others.

C. Tapping and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instrumentation furnished under this Division are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage, and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17500 – Enclosures, General

C. Section 17600 – Unpowered Instruments, General

D. Section 17698 – Instrumentation and Control System Accessories

E. Section 17800 – Analytical Instruments, General

F. Powered instruments furnished with mechanical equipment shall be furnished, installed, tested and calibrated as specified elsewhere in the Contract Documents.

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. The instrumentation subcontractor shall provide one remote handheld configuration device for communication with all "smart" instruments furnished under this Contract. The devices shall be capable of performing configuration, test, and format functions from anywhere on the 4-20 mA signal loop for a particular transmitter or by direct connection. The configuration device shall be Fischer & Porter Model 50HC1000, Rosemount Model 375, or equal.

PART 2 -- PRODUCTS

2.01 GENERAL

A. All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required.

B. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Drawings, to comply with the National Electrical Code.

C. All field instrumentation for outdoor service shall be provided with enclosures which are suitable for outdoor service, as follows:

1. Where the manufacturer's enclosures are suitable for outdoor service, they shall be provided with instrument sunshades. Sunshades shall be Style E as manufactured by O'Brien Corporation, or equal. Where possible, these instruments shall be mounted in a north facing direction.

2. Where the manufacturer's standard enclosures are not suitable for outdoor service, instruments shall be mounted in Field Panels in accordance with Section 17520, Field Panels, or may be furnished with Vipak instrument field enclosures as manufactured by O'Brien Corporation, equivalent by Intertec, or equal. It shall not be necessary to provide the manufacturer's NEMA 4 or 4X enclosures for instruments that will be subsequently mounted in separate field panels.

D. All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.

E. Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in Subsection 3.01 (B) herein. All indicator readouts shall be linear in process units. Readouts of 0-100% shall not be acceptable (except for speed and valve position). Isolated outputs shall be provided for all transmitters.

F. Unless otherwise specified, field instrument and power supply enclosures shall be 316 stainless steel, fiberglass or PVC coated copper-free cast aluminum NEMA 4X construction.

G. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.

H. Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for long-term performance and dependability over ambient atmosphere fluctuations. Ambient conditions shall be -20 to 50 degrees C and 20 to 100 percent relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

I. All devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.

J. All non-loop-powered instruments and equipment shall be designed to operate on a 60 Hz AC power source at a nominal 117 V, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

K. All analog transmitter and controller outputs shall be isolated, 4-20 milliamps into a load of 0-750 ohms, unless specifically noted otherwise. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless specified otherwise.

L. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. General

1. Equipment shall be located so that it is accessible for operation and maintenance. The instrumentation subcontractor shall examine the Drawings and shop drawings for various items of equipment in order to determine the best arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.

2. Electrical work shall be performed in compliance with all applicable local codes and practices. Where the Contract Documents do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

B. Equipment Mounting and Support

1. Field equipment shall be wall mounted or mounted on two-inch diameter pipe stands welded to a 10-inch square by 1/2-inch thick base plate unless shown adjacent to a wall or otherwise noted. Materials of construction shall be aluminum or 316 stainless steel. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2-inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.

2. Embedded pipe supports and sleeves shall be schedule 40, 316 stainless steel pipe, ASA B-36.19, with stainless steel blind flange for equipment mounting as shown on the Drawings.

3. Materials for miscellaneous mounting brackets and supports shall be 316 stainless steel construction.

4. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.

5. Transmitters shall be oriented such that output indicators are readily visible.

C. Control and Signal Wiring

1. Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid-tight flexible conduit. Conduit seals shall be provided where conduits enter all field instrument enclosures and all cabinetry housing electrical or electronic equipment.

3.02 ADJUSTMENT AND CLEANING

A. General

1. The instrumentation subcontractor shall comply with the requirements of Division 1 of these Specifications and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative(s), reserves the right to witness any test, inspection, calibration or start-up activity. Acceptance by the Engineer of any plan, report or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.

2. The instrumentation subcontractor shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the Owner. The Contractor shall bear all costs and provide all personnel, equipment and materials necessary

to implement all installation tests and inspection activities for equipment specified herein.

3. At least 60 days before the anticipated initiation of installation testing, the Contractor shall submit to the Engineer a detailed description, of the installation tests to be conducted to demonstrate the correct operation of the instrumentation supplied hereunder.

B. Field Instrument Calibration Requirements

1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate each instrument supplied under this Contract to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration.

2. If the manufacturer's recommendations require calibration, each instrument shall be calibrated at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy's as set forth by the National Institute for Standards and Technology (NIST).

3. The instrumentation subcontractor shall provide a written calibration sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made.

4. If doubt exists as to the correct method for calibrating or checking the calibration of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.

5. Upon completion of calibration, devices calibrated hereunder shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to overvoltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the Owner.

6. After completion of instrumentation installation, the instrumentation subcontractor shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

- END OF SECTION -

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SECTION 17740

ULTRASONIC LIQUID LEVEL MEASUREMENT SYSTEMS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the ultrasonic liquid level measurement systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17700 – Powered Instruments, General

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Furnish one hand-held programmer under this Contract to calibrate and configure the level controllers specified herein. The programmer shall be furnished complete with battery plus one spare battery, carrying case and accessories. Programmer shall be furnished by the level instrument manufacturer and shall be fully matched to the instrument furnished.

PART 2 -- PRODUCTS

2.01 ULTRASONIC LEVEL CONTROLLERS

A. Each ultrasonic level monitoring system shall include one ultrasonic level sensor and an "intelligent" transmitter (controller). The ultrasonic level monitoring system shall be required to monitor the level of process liquids or solids as shown on the Drawings and/or as specified herein. Location of the sensor and transmitters shall be as shown on the Drawings and/or as specified.

B. For outdoor installation, the use of approved watertight conduit hub/glands shall be required. Tank mounting applications shall include mounting flange adapter supplied by the manufacturer, which is compatible with the process media and the tank flange connection. Channel or wall mounting applications shall include mounting bracket supplied by the manufacturer and constructed of 316 stainless steel material. Sensor mounting thread shall be 1" NPT.

C. The level sensor shall be unaffected by moisture droplets on the transducer face and operate on the ultrasonic echo ranging principle. The sensor shall also be fully submersible and resistant to corrosive materials. Sensor accuracy shall be a minimum of 0.25 percent of level measurement range and include integral temperature compensation with an accuracy of 0.09% of range. Resolution shall be at least 0.1 percent of full range or 0.08 inches, whichever is greater.

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D. The transmitter shall be programmable by using a hand-held programmer. Display shall be LCD with backlighting, shall have the capability to display a minimum of 4 characters at one time, and shall be shielded from direct sunlight. The units shall have as a minimum, the required number of programmable set points to perform the functions specified. Each set point shall operate a set of contacts rated at 5 amps, 250 VAC, non-inductive.

E. The transmitter shall compensate for changes in temperature and air density. The controller shall be capable of performing the following functions: level monitor, both linear and nonlinear level to flow relationships, volumetric, open channel flow monitoring, differential control, and control of up to 6 pumps, alarms, monitor pump runtime and pump sequencing. Output level signal shall be linear, isolated 4-20 mA DC. Power requirement for the transmitter shall be 120 VAC, 60 Hz. The units shall have a NEMA 4X stainless steel or nonmetallic enclosure.

F. Ultrasonic level measurement system shall be the HydroRanger 200/Echomax Series Transducers by Siemens/Milltronics, or equal.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Where two or more ultrasonic level instruments are mounted in close proximity to each other, the transmitters shall coordinate operation to prevent interference from adjacent units. Coordination shall be accomplished via an interconnecting communication cable furnished by the manufacturer.

B. Where level transducers may become submerged, provide a manufacturer-supplied submergence hood.

C. Where ultrasonic level systems are used on solids measurement applications, provide a swiveling aiming device to allow easy adjustment of beam direction.

D. For open channel flow applications where the transducer is subject to direct sunlight, use an externally mounted temperature compensator mounted out of direct sunlight.

E. Refer to Section 17700, Part 3 of the specifications for additional requirements.

- END OF SECTION -

SECTION 17760

PRESSURE INDICATING TRANSMITTERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the pressure indicating transmitters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17700 – Powered Instruments, General

PART 2 -- PRODUCTS

2.01 GAUGE PRESSURE INDICATING TRANSMITTERS

A. Gauge pressure transmitters shall be of the capacitance type with a process-isolated diaphragm with silicone oil fill, microprocessor-based "smart" electronics, and a field adjustable rangeability of 100:1 input range. Span and zero shall be continuously adjustable externally over the entire range. Span and zero adjustments shall be capable of being disabled internally. Transmitters shall be NEMA 4X weatherproof and corrosion resistant construction with low-copper aluminum body and 316 stainless steel process wetted parts. Accuracy, including nonlinearity, hysteresis and repeatability errors shall be plus or minus 0.025 percent of calibrated span, zero based. The maximum zero elevation and maximum zero suppression shall be adjustable to anywhere within sensor limits. Output shall be linear isolated 4-20 milliamperes 24 VDC. Power supply shall be 24 VDC, two-wire design. Each transmitter shall be furnished with a 4-digit LCD indicator capable of displaying engineering units and/or milliamps and mounting hardware as required. Overload capacity shall be rated at a minimum of 25 MPa. Environmental limits shall be -40 to 85 degrees Celsius at 0-100% relative humidity. Each transmitter shall have a stainless steel tag with calibration data attached to body.

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B. The piezoresistive silicon pressure sensor shall be mechanically, electrically, and thermally isolated from the process and the environment, shall include an integral temperature compensation sensor, and shall provide a digital signal to the transmitter's electronics for further processing. Factory set correction coefficients shall be stored in the sensor's non-volatile memory for correction and linearization of the sensor output in the electronics section. The electronics section shall correct the digital signal from the sensor and convert it into a 4-20 mA analog signal for transmission to receiving devices. The electronics section shall contain configuration parameters and diagnostic data in non-volatile EEPROM memory and shall be capable of communicating, via a digital signal superimposed on the 4-20 mA output signal, with a remote interface device. Output signal damping shall be provided, with an adjustable time constant of 0-36 seconds. Total long term stability (frequency of calibration) shall be not less than 0.20% URL for 15 years.

C. Where scheduled, gauge pressure indicating transmitters shall be calibrated in feet of liquid for liquid level service.

D. Gauge pressure indicating transmitters shall be Model 3051S1TG as manufactured by Emerson Process Management (Rosemount), or equal.

2.02 DIFFERENTIAL PRESSURE INDICATING TRANSMITTERS

A. Differential pressure indicating transmitters shall be the same as the gauge pressure transmitters except for body specifications. Differential pressure units shall be furnished with close coupled stainless steel three valve manifold assembly.

B. The electronics sections of differential pressure transmitters shall contain user-selectable square root extractors to provide a linear 4-20 mA DC output proportional to flow, when activated. Square root extractor circuitry shall be activated only for incompressible fluid flow applications (i.e., water). Flow rates for compressible fluids (i.e., air) shall be calculated externally using line temperature and static pressure corrections as specified elsewhere in Division 17. In addition, each flow transmitter shall be furnished with laminated flow versus differential pressure curves wall mounted adjacent to the transmitter.

C. Differential pressure indicating transmitters shall be Model 3051S1CG as manufactured by Emerson Process Management (Rosemount), or equal.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17700, Part 3 of the Specifications.

- END OF SECTION -

SECTION 17770

TEMPERATURE INDICATING TRANSMITTERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the temperature indicating transmitters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 - Control and Information System Scope and General Requirements

B. Section 17700 - Powered Instruments, General

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Furnish one Transmation Model 1074 RTD Calibrator with all accessories.

PART 2 -- PRODUCTS

2.01 TEMPERATURE INDICATING TRANSMITTERS

A. Temperature indicating-transmitters shall be microprocessor-based with "smart" electronics, capable of accepting direct inputs from 2-, 3-, or 4-wire, platinum, copper, or nickel resistance temperature detectors (RTD) from 10 to 1000 ohms, thermocouple inputs, direct millivolt sources, and resistance/potentiometer devices. The indicating-transmitter shall be a true 2-wire device capable of operating on voltages up to 45 VDC.

B. The accuracy of the transmitter's Digital-to-Analog converter shall be within 0.02 percent of span. An LCD digital display shall be provided, capable of displaying mA, degrees in any units, ohms, or mV. Digital accuracy (Pt 100 RTD) shall be 0.10 degrees C. The indicator-transmitter shall contain an analog-to-digital converter which shall convert the RTD input to a digital signal and send it to the transmitter's electronics for further processing. Factory set correction coefficients shall be stored in the sensor's non-volatile memory for correction and linearization of the sensor output in the electronics section. The electronics section shall correct the digital signal from the sensor and convert it into a 4-20 mA analog signal for transmission to receiving devices. The electronics section shall contain configuration parameters and diagnostic data in non-volatile EEPROM memory and shall be capable of communicating, via a digital signal superimposed on the 4-20 mA output signal, with a remote interface device. Output signal damping shall be provided, with an adjustable time constant of 0-36 seconds. Long term stability (frequency of calibration) shall be not less than 0.25% of reading or 0.25 degrees C for five years.

C. The transmitter assembly shall be furnished with all necessary hardware for proper mounting as recommended by the manufacturer. Indicating-transmitter shall be housed in a watertight enclosure meeting NEMA 4X requirements. Enclosure shall be suitable for wall or 2-inch pipe stand mounting.

D. The transmitter shall provide a linear isolated 4-20 mADC output proportional to temperature.

E. The transmitter shall constantly monitor all aspects of the input circuitry and diagnose any system failures. If self-diagnostics detect a sensor burnout or transmitter failure, the analog output signal shall be driven either upscale or downscale to alert the user. Upscale and downscale burnout features shall be user-selectable.

F. Temperature measurement system shall be Model 3144P as manufactured by Rosemount Engineering Co., or equal.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17700, Part 3 of the Specifications.

- END OF SECTION -

SECTION 17800

ANALYTICAL INSTRUMENTS, GENERAL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The instrumentation subcontractor shall furnish, install, test and place in operation the analytical instruments as scheduled in the following sections together with all signal converters, transmitters, isolators, amplifiers, etc. to interface with the process control system as shown on the Drawings and as specified. The Contractor may elect to install sensors on process lines provided that the instrumentation subcontractor provides full on-site supervision during installation. Mounting of associated indicators, sensors, sampling pumps, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The instrumentation subcontractor shall supervise installation of equipment provided under this Section where installation is provided by others.

C. Tapping and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the analytical instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instruments furnished under this Section are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17500 – Enclosures, General

C. Section 17600 – Unpowered Instruments General

D. Section 17698 – Instrumentation and Control System Accessories

E. Section 17700 – Powered Instruments General

F. Analytical instruments furnished with mechanical equipment shall be furnished, installed, tested and calibrated as specified elsewhere in the Contract Documents.

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050.

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B. Additional items as recommended by the analytical instrument manufacturers or as described for the specified analytical instrument sections shall be provided.

PART 2 -- PRODUCTS

2.01 GENERAL

A. All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required.

B. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Drawings, to comply with the National Electrical Code.

C. All field instrumentation for outdoor service shall be provided with enclosures that are suitable for outdoor service, as follows:

1. Where the manufacturer's enclosures are suitable for outdoor service, they shall be provided with instrument sunshades. Sunshades shall be Style E as manufactured by O'Brien Corporation, or equal. Where possible, these instruments shall be mounted in a north facing direction.

2. Where the manufacturer's standard enclosures are not suitable for outdoor service, instruments shall be mounted in Field Panels in accordance with Section 17520, Field Panels, or may be furnished with Vipak instrument field enclosures as manufactured by O'Brien Corporation, equivalent by Intertec, or equal. It shall not be necessary to provide the manufacturer's NEMA 4 or 4X enclosures for instruments that will be subsequently mounted in separate field panels.

D. All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.

E. Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in Subsection 3.01 B herein. All indicator readouts shall be linear in process units. Readouts of 0-100% shall not be acceptable (except for speed and valve position). Isolated outputs shall be provided for all transmitters.

F. Unless otherwise specified, field instrument and power supply enclosures shall be 316 stainless steel, fiberglass (or equivalent) or PVC coated copper-free cast aluminum NEMA 4X construction.

G. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.

H. Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for long-term performance and dependability over ambient atmosphere fluctuations. Ambient conditions shall be -20 to 50 degrees C and 20 to 100 percent relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

I. All devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.

J. All non-loop-powered instruments and equipment shall be designed to operate on a 60 Hz AC power source at a nominal 117 V, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

K. All analog transmitter and controller outputs shall be isolated, 4-20 milliamps into a load of 0-750 ohms, unless specifically noted otherwise. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless specified otherwise.

L. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.

2.02 ANALYSIS INSTRUMENTS

A. Liquid samples shall not pass through housings containing analyzer electronics. Process fluid temperature will be within a range of 40 to 90 degrees F.

B. Where ambient temperatures will affect accuracy by more than 1 percent of span, a suitable isothermal enclosure with thermostatically controlled space heater shall be provided.

C. Sample assemblies shall be suitable for submersion or flow-through service as noted and shall be chemically inert to constituents of raw wastewater solids or other chemical environment, as scheduled. Where the sample is drawn prior to filtration, the sample assemblies shall be capable of handling solids and grease.

D. Each analyzer requiring reagents and/or other replaceable parts shall be furnished with sufficient chemicals and replaceable parts for startup and acceptance tests and the specified warranty period.

E. Contractor's submittals on these analyzers shall include information on monthly reagent consumption and a list of replaceable parts required for periodic maintenance and the recommended operating periods between replacements. Installation of analyzers and sample preparation shall be in accordance with the analyzer manufacturer's instructions.

F. Analysis instrumentation performance, accuracy and reproducibility shall be as prescribed in APHA/AWWA/WEF "Standard Methods for the Examination of Water and Wastewater", latest edition. For those measurements specified herein, for which performance characteristics are not listed in the above, the supplier shall state instrument performance characteristics. The "referee" method shall be as prescribed in EPA Methods for Chemical Analysis of Water and Wastes (1971).

PART 3 -- EXECUTION

3.01 INSTALLATION

A. General

1. Equipment shall be located so that it is accessible for operation and maintenance. The instrumentation subcontractor shall examine the Drawings and shop drawings for various items of equipment in order to determine the best arrangement for the work as a whole and shall supervise the installation of process instrumentation supplied under this Division.

2. Electrical work shall be performed in compliance with all applicable local codes and practices. Where these specifications and the Drawings do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

B. Equipment Mounting and Support

1. Field equipment shall be wall mounted or mounted on two-inch diameter pipe stands welded to a 10-inch square by 1/2-inch thick base plate unless shown adjacent to a wall or otherwise noted. Materials of construction shall be aluminum or 316 stainless steel. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2-inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.

2. Embedded pipe supports and sleeves shall be Schedule 40, Type 316 stainless steel pipe, ASA B-36.19, with stainless steel blind flange for equipment mounting as shown on the Drawings.

3. Materials for miscellaneous mounting brackets and supports shall be 316 stainless steel construction.

4. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.

5. Transmitters shall be oriented such that output indicators are readily visible.

C. Control and Signal Wiring

1. Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid-tight flexible conduit. Conduit seals shall be provided where conduits enter all field instrument enclosures and all cabinetry housing electrical or electronic equipment.

3.02 ADJUSTMENT AND CLEANING

A. The instrumentation subcontractor shall comply with the requirements of Division 1 of these Specifications and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative(s), reserves the right to witness any test, inspection, calibration or start-up activity. Acceptance by the Engineer of any plan, report or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.

B. The instrumentation subcontractor shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the Owner. The Contractor shall bear all costs and provide all personnel, equipment and materials necessary to implement all installation tests and inspection activities for equipment specified herein.

C. At least 60 days before the anticipated initiation of installation testing, the Contractor shall submit to the Engineer a detailed description, in duplicate, of the installation tests to be conducted to demonstrate the correct operation of the instrumentation supplied hereunder.

D. Field instrument calibration shall conform to the following requirements:

1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate each instrument supplied under this Contract to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration.

2. Each instrument shall be calibrated at 0, 25, 50, 75 and 100 percent of span using test instruments and specified chemicals of known values to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy’s as set forth by the National Institute for Standards and Technology (NIST).

3. The instrumentation subcontractor shall provide a written calibration sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made.

4. If doubt exists as to the correct method for calibrating or checking the calibration of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.

5. Upon completion of calibration, devices calibrated hereunder shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to overvoltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the Owner.

6. After completion of instrumentation installation, the instrumentation subcontractor shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

- END OF SECTION -

SECTION 17811

LUMINESCENT DISSOLVED OXYGEN ANALYZERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the dissolved oxygen analyzers with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17800 – Analytical Instruments, General

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. One complete spare sensor of each type used shall be provided.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Dissolved oxygen sensors shall be of the luminescent type.

B. Handrail-mounting hardware for the D.O. sensors, analyzers, and cleaning systems shall be furnished by the manufacturer for each sensor location, as shown on the Drawings. Mounting hardware for the D.O. sensors shall be installed by the Contractor in accordance with the manufacturer's requirements and recommendations. D.O. analyzer mounting hardware shall be the manufacturer's standard mounting hardware, shall allow the probe to be removed from the process without tools so that it may be cleaned, and shall secure and cushion the probe's signal cable to ensure it does not get damaged as the probe moves in the process tank. Mounting hardware shall submerge the sensor head 12 to 24 inches below the water surface.

2.02 LUMINESCENT DISSOLVED OXYGEN SENSORS

A. Luminescent-type sensors shall be based on luminescent technology where green light from an LED is directed onto a luminescent coating on the sensor cap.

B. Probes shall be factory calibrated. Calibration shall be performed via single-point procedure in 100% water saturated air. No field calibration shall be required.

C. Probes shall have an integral temperature sensor with its data made available to the controller.

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D. The sensor shall be submersible and shall consist of a stainless steel probe body with a replaceable sensor head assembly coated with luminescent material. Provide a sensor cable of the required length for installation with a quick disconnect plug for connection to the analyzer. It shall be the Contractor's responsibility to determine and provide the proper length of cable between the transmitter and the sensor.

E. Sensor specifications shall be as follows:

1.	Accuracy:	± 0.05 ppm < 1 ppm DO ±0.1 ppm < 1 ppm DO
2.	Repeatability:	± 0.05 mg O_2/L
3.	Resolution:	0.01 ppm DO 0.1% saturation
4.	Measurement Range:	0-20.0 ppm
5.	Response Time:	<150 seconds
6.	Max. Immersion Depth:	34 m (112 ft) H_2O
7.	Operating Temp. Range:	-5 - 50°C

F. Dissolved oxygen sensors shall be the YSI FDO 700 IQ and intelligent sensor cap.

2.03 DISSOLVED OXYGEN CONTROLLERS

A. The microprocessor-based dissolved oxygen controller shall be compatible with the luminescent dissolved oxygen sensor. The controller shall receive a signal from the sensor, condition it, and amplify the signal for display and transmission.

B. Controllers shall meet the following minimum functional requirements:

1.	Housing:	NEMA 4X
2.	Power Supply:	115 VAC, 60 Hz
3.	Operating Temperature:	-20 to +55°C, 0-90% relative humidity, non-condensing

C. The controller shall have three relay contact outputs that can be configured based on the dissolved oxygen level. Relay outputs shall be programmable for various alarms and warning conditions that occurred internally within the system or with the process conditions. Relays shall be Form-C SPDT contacts rated at 5A, 115/230 VAC. The control and alarm setpoints for the relays shall be adjustable across the full operating range. LED lights at the controller shall indicate that the relay is energized. The analyzer shall have two linear, isolated 4-20mA assignable outputs. Where scheduled or otherwise specified, the controller shall be furnished with Modbus RS232/485, Profibus DP, or HART communication capability.

D. The controller display shall be transreflective dot matrix LCD display with LED backlight, 320 x 420 pixels. The controller shall have diagnostic screens for messages, including scrolling lists for failure and warning alarm conditions, calibration records, and hardware tests.

E. Dissolved oxygen controllers shall be the YSI MIQ/TC 2020 Universal Controller.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17800, Part 3 of the specifications.

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SECTION 17910

INSTRUMENT SCHEDULE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all instrumentation as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17920 – Control System Input/Output Schedule

B. Section 17950 – Functional Control Descriptions

PART 2 -- INSTRUMENT SCHEDULE

See attached Instrument Schedule 17910.

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Pressure/Differential Pressure Transmitters – Section 17760			
Tag Number	**Service Description**	**State/Span**	**Remarks**

Temperature Transmitters – Section 17770			
Tag Number	**Service Description**	**State/Span**	**Remarks**

Luminescent Dissolved Oxygen Analyzers – Section 17811			
Tag Number	**Service Description**	**State/Span**	**Remarks**

Pressure Gauges – Section 17650			
Tag Number	**Service Description**	**State/Span**	**Remarks**

Temperature Gauges – Section 17681			
Tag Number	**Service Description**	**State/Span**	**Remarks**

- END OF SECTION -

Tag	Service Description	Spec Section	Range/ Setpoint	Size	P&ID	Comment
PIT-1500	Blower Discharge Header Pressure Transmitter	17760	0 - 10 psig	36" line	I-100	
TIT-1500	Blower Discharge Header Temperature Transmitter	17770	0 - 300°F	36" line	I-100	
FE-2121	Aeration Tank 1 Zone 1 Insert Venturi	17610	0 - 7,500	16" line	I-200	
FE-2122	Aeration Tank 1 Zone 2 Insert Venturi	17610	0 - 7,500	16" line	I-200	
FE-2221	Aeration Tank 2 Zone 1 Insert Venturi	17610	0 - 12,000	20" line	I-200	
FE-2222	Aeration Tank 2 Zone 2 Insert Venturi	17610	0 - 12,000	20" line	I-200	
PDIT-2121	Aeration Tank 1 Zone 1 Flow (Pressure Differential) Transmitter	17760	0-25 inches H_2O		I-200	Instrument span must be coordinated with the differential pressure range produced by the corresponding Venturi Meter
PDIT-2122	Aeration Tank 1 Zone 2 Flow (Pressure Differential) Transmitter	17760	0-25 inches H_2O		I-200	
PDIT-2221	Aeration Tank 2 Zone 1 Flow (Pressure Differential) Transmitter	17760	0-25 inches H_2O		I-200	
PDIT-2222	Aeration Tank 2 Zone 2 Flow (Pressure Differential) Transmitter	17760	0-25 inches H_2O		I-200	
AE/AIT-2141	Aeration Tank 1 Zone 1 DO Probe and Transmitter	17811	0-10 mg/L		I-200	
AE/AIT-2142	Aeration Tank 1 Zone 2 DO Probe and Transmitter	17811	0-10 mg/L		I-200	
AE/AIT-2241	Aeration Tank 2 Zone 1 DO Probe and Transmitter	17811	0-10 mg/L		I-200	
AE/AIT-2242	Aeration Tank 2 Zone 2 DO Probe and Transmitter	17811	0-10 mg/L		I-200	
LE/LIT-2500	Junction Structure Ultrasonic Level Transmitter	17740	0-10 feet		I-250	

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SECTION 17920

CONTROL SYSTEM INPUT/OUTPUT SCHEDULE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all control system inputs and outputs as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17910 – Instrument Schedule (see attached)

Notes:

1. Input/Output types are as follows:

DI	-	Discrete Input
DO	-	Discrete Output
AI	-	Analog Input
AO	-	Analog Output
DDI	-	Digital Discrete Input
DDO	-	Digital Discrete Output
DAI	-	Digital Analog Input
DAO	-	Digital Analog Output
RS485	-	Serial Communications Link

- END OF SECTION -

080805BR

I/O Tag	Service Description	Function	PLC	I/O Type	P&ID	Comments
EI-1600	SWBD-3 Utility	Voltage	PLC-10	DAI	I-100	
II-1600A	SWBD-3 Utility	Current	PLC-10	DAI	I-100	
II-1600B	SWBD-3 Utility	Frequency	PLC-10	DAI	I-100	
JI-1600A	SWBD-3 Utility	Power (kW)	PLC-10	DAI	I-100	
JI-1600B	SWBD-3 Utility	Power Factor (PF)	PLC-10	DAI	I-100	
YI-1700	SWBD-3 Generator	Run	PLC-10	DDI	I-100	
YA-1700A	SWBD-3 Generator	Fault	PLC-10	DDI	I-100	
YA-1700B	SWBD-3 Generator	Low Fuel	PLC-10	DDI	I-100	
YI-1800A	AC Unit No. 1 Blower	Run	PLC-10	DI	I-100	
YA-1800A	AC Unit No. 1 Blower	Fault	PLC-10	DI	I-100	
YI-1800B	AC Unit No. 2 Blower	Run	PLC-10	DI	I-100	
YA-1800B	AC Unit No. 2 Blower	Fault	PLC-10	DI	I-100	
HS-1100B	Blower 1 (B-1100)	Start	PLC-10	DDO	I-100	
HS-1100C	Blower 1 (B-1100)	Stop	PLC-10	DDO	I-100	
YI-1100A	Blower 1 (B-1100)	Run	PLC-10	DDI	I-100	
YI-1100B	Blower 1 (B-1100)	In Remote	PLC-10	DDI	I-100	
YA-1100	Blower 1 (B-1100)	Fault	PLC-10	DDI	I-100	
TI-1100A	Blower 1 (B-1100)	Inlet Air Temperature	PLC-10	DAI	I-100	
TI-1101A	Blower 1 (B-1100)	Motor Windings Temperature	PLC-10	DAI	I-100	
TI-1101B	Blower 1 (B-1100)	Motor Windings Temperature	PLC-10	DAI	I-100	
TI-1101C	Blower 1 (B-1100)	Motor Windings Temperature	PLC-10	DAI	I-100	
TI-1101D	Blower 1 (B-1100)	Motor Windings Temperature	PLC-10	DAI	I-100	
TI-1101E	Blower 1 (B-1100)	Motor Windings Temperature	PLC-10	DAI	I-100	
TI-1101F	Blower 1 (B-1100)	Motor Windings Temperature	PLC-10	DAI	I-100	
VI-1101A	Blower 1 (B-1100)	Motor Bearing Vibration	PLC-10	DAI	I-100	

VI-1101B	Blower 1 (B-1100)	Motor Bearing Vibration	PLC-10	DAI	I-100
II-1100A	Blower 1 (B-1100)	Current	PLC-10	DAI	I-100
II-1100B	Blower 1 (B-1100)	Horsepower	PLC-10	DAI	I-100
TI-1102A	Blower 1 (B-1100)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1102B	Blower 1 (B-1100)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1103A	Blower 1 (B-1100)	Blower Bearing Temperature	PLC-10	DAI	I-100
TI-1103B	Blower 1 (B-1100)	Blower Bearing Temperature	PLC-10	DAI	I-100
VI-1103A	Blower 1 (B-1100)	Blower Bearing Vibration	PLC-10	DAI	I-100
VI-1103B	Blower 1 (B-1100)	Blower Bearing Vibration	PLC-10	DAI	I-100
TI-1100B	Blower 1 (B-1100)	Discharge Air Temperature	PLC-10	DAI	I-100
PDI-1100	Blower 1 (B-1100)	Inlet Filter Differential Pressure	PLC-10	DAI	I-100
HZC-1110	Blower 1 Inlet Valve (MOV-1110)	Valve Position Control	PLC-10	DAO	I-100
ZI-1110	Blower 1 Inlet Valve (MOV-1110)	Valve Position Indication	PLC-10	DAI	I-100
YI-1110	Blower 1 Inlet Valve (MOV-1110)	Valve in Remote	PLC-10	DDI	I-100
YA-1110	Blower 1 Inlet Valve (MOV-1110)	Valve Fault	PLC-10	DDI	I-100
HS-1200B	Blower 2 (B-1200)	Start	PLC-10	DDO	I-100
HS-1200C	Blower 2 (B-1200)	Stop	PLC-10	DDO	I-100
YI-1200A	Blower 2 (B-1200)	Run	PLC-10	DDI	I-100
YI-1200B	Blower 2 (B-1200)	In Remote	PLC-10	DDI	I-100
YA-1200	Blower 2 (B-1200)	Fault	PLC-10	DDI	I-100

TI-1200A	Blower 2 (B-1200)	Inlet Air Temperature	PLC-10	DAI	I-100
TI-1201A	Blower 2 (B-1200)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1201B	Blower 2 (B-1200)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1201C	Blower 2 (B-1200)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1201D	Blower 2 (B-1200)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1201E	Blower 2 (B-1200)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1201F	Blower 2 (B-1200)	Motor Windings Temperature	PLC-10	DAI	I-100
VI-1201A	Blower 2 (B-1200)	Motor Bearing Vibration	PLC-10	DAI	I-100
VI-1201B	Blower 2 (B-1200)	Motor Bearing Vibration	PLC-10	DAI	I-100
II-1200A	Blower 2 (B-1200)	Current	PLC-10	DAI	I-100
II-1200B	Blower 2 (B-1200)	Horsepower	PLC-10	DAI	I-100
TI-1202A	Blower 2 (B-1200)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1202B	Blower 2 (B-1200)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1203A	Blower 2 (B-1200)	Blower Bearing Temperature	PLC-10	DAI	I-100
TI-1203B	Blower 2 (B-1200)	Blower Bearing Temperature	PLC-10	DAI	I-100
VI-1203A	Blower 2 (B-1200)	Blower Bearing Vibration	PLC-10	DAI	I-100
VI-1203B	Blower 2 (B-1200)	Blower Bearing Vibration	PLC-10	DAI	I-100
TI-1200B	Blower 2 (B-1200)	Discharge Air Temperature	PLC-10	DAI	I-100

PDI-1200	Blower 2 (B-1200)	Inlet Filter Differential Pressure	PLC-10	DAI	I-100
HZC-1210	Blower 2 Inlet Valve (MOV-1210)	Valve Position Control	PLC-10	DAO	I-100
ZI-1210	Blower 2 Inlet Valve (MOV-1210)	Valve Position Indication	PLC-10	DAI	I-100
YI-1210	Blower 2 Inlet Valve (MOV-1210)	Valve in Remote	PLC-10	DDI	I-100
YA-1210	Blower 2 Inlet Valve (MOV-1210)	Valve Fault	PLC-10	DDI	I-100
HS-1300B	Blower 3 (B-1300)	Start	PLC-10	DDO	I-100
HS-1300C	Blower 3 (B-1300)	Stop	PLC-10	DDO	I-100
YI-1300A	Blower 3 (B-1300)	Run	PLC-10	DDI	I-100
YI-1300B	Blower 3 (B-1300)	In Remote	PLC-10	DDI	I-100
YA-1300	Blower 3 (B-1300)	Fault	PLC-10	DDI	I-100
TI-1300A	Blower 3 (B-1300)	Inlet Air Temperature	PLC-10	DAI	I-100
TI-1301A	Blower 3 (B-1300)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1301B	Blower 3 (B-1300)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1301C	Blower 3 (B-1300)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1301D	Blower 3 (B-1300)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1301E	Blower 3 (B-1300)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1301F	Blower 3 (B-1300)	Motor Windings Temperature	PLC-10	DAI	I-100
VI-1301A	Blower 3 (B-1300)	Motor Bearing Vibration	PLC-10	DAI	I-100
VI-1301B	Blower 3 (B-1300)	Motor Bearing Vibration	PLC-10	DAI	I-100
II-1300A	Blower 3 (B-1300)	Current	PLC-10	DAI	I-100

II-1300B	Blower 3 (B-1300)	Horsepower	PLC-10	DAI	I-100
TI-1302A	Blower 3 (B-1300)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1302B	Blower 3 (B-1300)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1303A	Blower 3 (B-1300)	Blower Bearing Temperature	PLC-10	DAI	I-100
TI-1303B	Blower 3 (B-1300)	Blower Bearing Temperature	PLC-10	DAI	I-100
VI-13203A	Blower 3 (B-1300)	Blower Bearing Vibration	PLC-10	DAI	I-100
VI-1303B	Blower 3 (B-1300)	Blower Bearing Vibration	PLC-10	DAI	I-100
TI-1300B	Blower 3 (B-1300)	Discharge Air Temperature	PLC-10	DAI	I-100
PDI-1300	Blower 3 (B-1300)	Inlet Filter Differential Pressure	PLC-10	DAI	I-100
HZC-1310	Blower 3 Inlet Valve (MOV-1310)	Valve Position Control	PLC-10	DAO	I-100
ZI-1310	Blower 3 Inlet Valve (MOV-1310)	Valve Position Indication	PLC-10	DAI	I-100
YI-1310	Blower 3 Inlet Valve (MOV-1310)	Valve in Remote	PLC-10	DDI	I-100
YA-1310	Blower 3 Inlet Valve (MOV-1310)	Valve Fault	PLC-10	DDI	I-100
HS-1400B	Blower 4 (B-1400)	Start	PLC-10	DDO	I-100
HS-1400C	Blower 4 (B-1400)	Stop	PLC-10	DDO	I-100
YI-1400A	Blower 4 (B-1400)	Run	PLC-10	DDI	I-100
YI-1400B	Blower 4 (B-1400)	In Remote	PLC-10	DDI	I-100
YA-1400	Blower 4 (B-1400)	Fault	PLC-10	DDI	I-100
TI-1400A	Blower 4 (B-1400)	Inlet Air Temperature	PLC-10	DAI	I-100
TI-1401A	Blower 4 (B-1400)	Motor Windings Temperature	PLC-10	DAI	I-100

TI-1401B	Blower 4 (B-1400)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1401C	Blower 4 (B-1400)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1401D	Blower 4 (B-1400)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1401E	Blower 4 (B-1400)	Motor Windings Temperature	PLC-10	DAI	I-100
TI-1401F	Blower 4 (B-1400)	Motor Windings Temperature	PLC-10	DAI	I-100
VI-1401A	Blower 4 (B-1400)	Motor Bearing Vibration	PLC-10	DAI	I-100
VI-1401B	Blower 4 (B-1400)	Motor Bearing Vibration	PLC-10	DAI	I-100
II-1400A	Blower 4 (B-1400)	Current	PLC-10	DAI	I-100
II-1400B	Blower 4 (B-1400)	Horsepower	PLC-10	DAI	I-100
TI-1402A	Blower 4 (B-1400)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1402B	Blower 4 (B-1400)	Motor Bearing Temperature	PLC-10	DAI	I-100
TI-1403A	Blower 4 (B-1400)	Blower Bearing Temperature	PLC-10	DAI	I-100
TI-1403B	Blower 4 (B-1400)	Blower Bearing Temperature	PLC-10	DAI	I-100
VI-14203A	Blower 4 (B-1400)	Blower Bearing Vibration	PLC-10	DAI	I-100
VI-1403B	Blower 4 (B-1400)	Blower Bearing Vibration	PLC-10	DAI	I-100
TI-1400B	Blower 4 (B-1400)	Discharge Air Temperature	PLC-10	DAI	I-100
PDI-1400	Blower 4 (B-1400)	Inlet Filter Differential Pressure	PLC-10	DAI	I-100
HZC-1410	Blower 4 Inlet Valve (MOV-1410)	Valve Position Control	PLC-10	DAO	I-100

ZI-1410	Blower 4 Inlet Valve (MOV-1410)	Valve Position Indication	PLC-10	DAI	I-100
YI-1410	Blower 4 Inlet Valve (MOV-1410)	Valve in Remote	PLC-10	DDI	I-100
YA-1410	Blower 4 Inlet Valve (MOV-1410)	Valve Fault	PLC-10	DDI	I-100
			PLC-10		
TI-1500	Blower Discharge Common Header	Temperature	PLC-10	AI	I-100
PI-1500	Blower Discharge Common Header	Pressure	PLC-10	AI	I-100
AI-2141	Aeration Tank 1 Zone 1	Dissolved Oxygen Level	PLC-30	AI	I-200
AI-2142	Aeration Tank 1 Zone 2	Dissolved Oxygen Level	PLC-30	AI	I-200
AI-2241	Aeration Tank 2 Zone 1	Dissolved Oxygen Level	PLC-30	AI	I-200
AI-2242	Aeration Tank 2 Zone 2	Dissolved Oxygen Level	PLC-30	AI	I-200
FI-2121	Aeration Tank 1 Zone 1	Aeration Air Flow	PLC-30	AI	I-200
FI-2122	Aeration Tank 1 Zone 2	Aeration Air Flow	PLC-30	AI	I-200
FI-2221	Aeration Tank 2 Zone 1	Aeration Air Flow	PLC-30	AI	I-200
FI-2222	Aeration Tank 2 Zone 2	Aeration Air Flow	PLC-30	AI	I-200
YI-2121	Aeration Air Valve MOV-2121	In Remote	PLC-10	DI	I-200
YA-2121	Aeration Air Valve MOV-2121	Fault	PLC-10	DI	I-200
ZI-2121	Aeration Air Valve MOV-2121	Position Feedback	PLC-10	AI	I-200
HZC-2121	Aeration Air Valve MOV-2121	Position Command	PLC-10	AO	I-200

YI-2122	Aeration Air Valve MOV-2122	In Remote	PLC-10	DI	I-200
YA-2122	Aeration Air Valve MOV-2122	Fault	PLC-10	DI	I-200
ZI-2122	Aeration Air Valve MOV-2122	Position Feedback	PLC-10	AI	I-200
HZC-2122	Aeration Air Valve MOV-2122	Position Command	PLC-10	AO	I-200
YI-2221	Aeration Air Valve MOV-2221	In Remote	PLC-10	DI	I-200
YA-2221	Aeration Air Valve MOV-2221	Fault	PLC-10	DI	I-200
ZI-2221	Aeration Air Valve MOV-2221	Position Feedback	PLC-10	AI	I-200
HZC-2221	Aeration Air Valve MOV-2221	Position Command	PLC-10	AO	I-200
YI-2222	Aeration Air Valve MOV-2222	In Remote	PLC-10	DI	I-200
YA-2222	Aeration Air Valve MOV-2222	Fault	PLC-10	DI	I-200
ZI-2222	Aeration Air Valve MOV-2222	Position Feedback	PLC-10	AI	I-200
HZC-2222	Aeration Air Valve MOV-2222	Position Command	PLC-10	AO	I-200
HS-2131	Aeration Tank 1 Mixer MXR-2131	Start/Stop	PLC-14	DO	I-200
YI-2131A	Aeration Tank 1 Mixer MXR-2131	Run	PLC-14	DI	I-200
YI-2131B	Aeration Tank 1 Mixer MXR-2131	In Remote	PLC-14	DI	I-200

YA-2131A	Aeration Tank 1 Mixer MXR-2131	Fault	PLC-14	DI	I-200
YA-2131B	Aeration Tank 1 Mixer MXR-2131	E-Stopped	PLC-14	DI	I-200
HS-2132	Aeration Tank 1 Mixer MXR-2132	Start/Stop	PLC-14	DO	I-200
YI-2132A	Aeration Tank 1 Mixer MXR-2132	Run	PLC-14	DI	I-200
YI-2132B	Aeration Tank 1 Mixer MXR-2132	In Remote	PLC-14	DI	I-200
YA-2132A	Aeration Tank 1 Mixer MXR-2132	Fault	PLC-14	DI	I-200
YA-2132B	Aeration Tank 1 Mixer MXR-2132	E-Stopped	PLC-14	DI	I-200
HS-2133	Aeration Tank 1 Mixer MXR-2133	Start/Stop	PLC-14	DO	I-200
YI-2133A	Aeration Tank 1 Mixer MXR-2133	Run	PLC-14	DI	I-200
YI-2133B	Aeration Tank 1 Mixer MXR-2133	In Remote	PLC-14	DI	I-200
YA-2133A	Aeration Tank 1 Mixer MXR-2133	Fault	PLC-14	DI	I-200
YA-2133B	Aeration Tank 1 Mixer MXR-2133	E-Stopped	PLC-14	DI	I-200
HS-2134	Aeration Tank 1 Mixer MXR-2134	Start/Stop	PLC-14	DO	I-200
YI-2134A	Aeration Tank 1 Mixer MXR-2134	Run	PLC-14	DI	I-200
YI-2134B	Aeration Tank 1 Mixer MXR-2134	In Remote	PLC-14	DI	I-200

YA-2134A	Aeration Tank 1 Mixer MXR-2134	Fault	PLC-14	DI	I-200
YA-2134B	Aeration Tank 1 Mixer MXR-2134	E-Stopped	PLC-14	DI	I-200
HS-2231	Aeration Tank 2 Mixer MXR-2231	Start/Stop	PLC-14	DO	I-200
YI-2231A	Aeration Tank 2 Mixer MXR-2231	Run	PLC-14	DI	I-200
YI-2231B	Aeration Tank 2 Mixer MXR-2231	In Remote	PLC-14	DI	I-200
YA-2231A	Aeration Tank 2 Mixer MXR-2231	Fault	PLC-14	DI	I-200
YA-2231B	Aeration Tank 2 Mixer MXR-2231	E-Stopped	PLC-14	DI	I-200
HS-2232	Aeration Tank 2 Mixer MXR-2232	Start/Stop	PLC-14	DO	I-200
YI-2232A	Aeration Tank 2 Mixer MXR-2232	Run	PLC-14	DI	I-200
YI-2232B	Aeration Tank 2 Mixer MXR-2232	In Remote	PLC-14	DI	I-200
YA-2232A	Aeration Tank 2 Mixer MXR-2232	Fault	PLC-14	DI	I-200
YA-2132B	Aeration Tank 2 Mixer MXR-2232	E-Stopped	PLC-14	DI	I-200
HS-2233	Aeration Tank 2 Mixer MXR-2233	Start/Stop	PLC-14	DO	I-200
YI-2233A	Aeration Tank 2 Mixer MXR-2233	Run	PLC-14	DI	I-200
YI-2233B	Aeration Tank 2 Mixer MXR-2233	In Remote	PLC-14	DI	I-200

YA-2233A	Aeration Tank 2 Mixer MXR-2233	Fault	PLC-14	DI	I-200
YA-2233B	Aeration Tank 2 Mixer MXR-2233	E-Stopped	PLC-14	DI	I-200
HS-2234	Aeration Tank 2 Mixer MXR-2234	Start/Stop	PLC-14	DO	I-200
YI-2234A	Aeration Tank 2 Mixer MXR-2234	Run	PLC-14	DI	I-200
YI-2234B	Aeration Tank 2 Mixer MXR-2234	In Remote	PLC-14	DI	I-200
YA-2234A	Aeration Tank 2 Mixer MXR-2234	Fault	PLC-14	DI	I-200
YA-2234B	Aeration Tank 2 Mixer MXR-2234	E-Stopped	PLC-14	DI	I-200
LI-2500	Junction Structure	Level	PLC-06	AI	I-250
HSO-2510	Final Clarifier Bypass Gate MOG-2510	Open Command	PLC-06	DO	I-250
HSC-2510	Final Clarifier Bypass Gate MOG-2510	Close Command	PLC-06	DO	I-250
YI-2510	Final Clarifier Bypass Gate MOG-2510	In Remote	PLC-06	DI	I-250
YA-2510	Final Clarifier Bypass Gate MOG-2510	Fault	PLC-06	DI	I-250
ZIC-2510	Final Clarifier Bypass Gate MOG-2510	Open Position	PLC-06	DI	I-250
ZIO-2510	Final Clarifier Bypass Gate MOG-2510	Closed Position	PLC-06	DI	I-250
HSO-2520	Final Clarifier Bypass Gate MOG-2520	Open Command	PLC-06	DO	I-250

HSC-2520	Final Clarifier Bypass Gate MOG-2520	Close Command	PLC-06	DO	I-250
YI-2520	Final Clarifier Bypass Gate MOG-2520	In Remote	PLC-06	DI	I-250
YA-2520	Final Clarifier Bypass Gate MOG-2520	Fault	PLC-06	DI	I-250
ZIC-2520	Final Clarifier Bypass Gate MOG-2520	Open Position	PLC-06	DI	I-250
ZIO-2520	Final Clarifier Bypass Gate MOG-2520	Closed Position	PLC-06	DI	I-250
ZIO-2610	Final Clarifier Distribution Gate SG-2610	Full Open Position	PLC-06	DI	I-250
ZIC-2610	Final Clarifier Distribution Gate SG-2610	Full Closed Position	PLC-06	DI	I-250
YA-2610	Final Clarifier Distribution Gate SG-2610	Fault	PLC-06	DI	I-250
ZIO-2620	Final Clarifier Distribution Gate SG-2620	Full Open Position	PLC-06	DI	I-250
ZIC-2620	Final Clarifier Distribution Gate SG-2620	Full Closed Position	PLC-06	DI	I-250
YA-2620	Final Clarifier Distribution Gate SG-2620	Fault	PLC-06	DI	I-250
ZIO-2630	Final Clarifier Distribution Gate SG-2630	Full Open Position	PLC-06	DI	I-250

ZIC-2630	Final Clarifier Distribution Gate SG-2630	Full Closed Position	PLC-06	DI	I-250
YA-2630	Final Clarifier Distribution Gate SG-2630	Fault	PLC-06	DI	I-250
ZIO-2640	Final Clarifier Distribution Gate SG-2640	Full Open Position	PLC-06	DI	I-250
ZIC-2640	Final Clarifier Distribution Gate SG-2640	Full Closed Position	PLC-06	DI	I-250
YA-2640	Final Clarifier Distribution Gate SG-2640	Fault	PLC-06	DI	I-250
AI-2551	Aeration Tank Effluent TSS	Indication	PLC-06	AI	I-250
AI-2552	Aeration Tank Effluent NH_3	Indication	PLC-06	AI	I-250
AI-2553	Aeration Tank Effluent NO3	Indication	PLC-06	AI	I-250

SECTION 17950

FUNCTIONAL CONTROL DESCRIPTIONS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all equipment as herein specified and as shown on the Drawings. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING COMPLETE FUNCTIONING SYSTEMS AS DESCRIBED HEREIN.

B. Together with the control system input/output schedule, the equipment specifications (including functional descriptions for local equipment control panels), and the Drawings, the functional control descriptions describe the required operation, monitoring, and control of the facilities included in this Contract.

C. THE FUNCTIONAL DESCRIPTIONS CONTAIN REQUIREMENTS FOR FURNISHING AND INSTALLING LABOR AND MATERIALS THAT MAY NOT APPEAR ELSEWHERE IN THE CONTRACT DOCUMENTS.

D. All equipment and services required in equipment local control panels provided to implement the monitoring and control functions described herein or in the process input/output schedules shall be provided by the Contractor through individual equipment suppliers.

E. Unless specifically stated otherwise, all interconnected wiring between all instruments, panels, controls, and other devices listed in the functional descriptions as required to provide all functions specified herein shall be furnished by the electrical subcontractor under Division 16. The electrical subcontractor shall provide all cable and conduit required to carry all signals listed in the process input/output schedules. Special cables that are required for interconnection between sensors or probes and transmitters or signal conditioners shall be furnished with the instrumentation devices by the equipment supplier.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01520 – Maintenance of Utility Operations During Construction

B. Section 17910 – Instrument Schedule

C. Section 17920 – Control System Input/Output Schedule

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PART 2 -- FUNCTIONAL CONTROL DESCRIPTIONS, GENERAL

2.01 DEFINITIONS

A. RUNNING status signals shall be from auxiliary contacts provided with the motor control equipment (i.e., starter, VFD, SCR, etc.).

B. AUTO status signals shall be defined as HAND-OFF-AUTO switch in the AUTO position or process control system in AUTO (versus MANUAL).

C. FAIL status signals shall be defined as motor overload and/or any other shut down mode such as overtorque, overtemperature, low oil pressure, high vibration, etc.

D. READY status signal shall be defined as all conditions, including equipment control power, satisfied to permit remote control of the equipment.

2.02 CONVENTIONS

A. Operator workstation graphic display symbols and indicator lights on all MCC's, control panels, starter enclosures, etc. shall conform to the following color convention:

Condition	Color
Running/On/Open	Red
Auto/Ready	White
Stopped/Off/Closed	Green
Fail/Alarm	Amber
Generic Status	Blue or White

2.03 PROCESS CONTROL

A. Where setpoints, operating limits, and other control settings are provided by the functional descriptions, these settings shall be initial settings only and shall be used for assistance in the initial startup of the plant. All such settings shall be fully adjustable and, based on actual operating conditions, the instrumentation subcontractor shall make all necessary adjustments to provide smooth, stable operation at no additional cost to the Owner.

B. Provision shall be made in PLC logic to suppress nuisance alarms and control actions by the following means:

1. For alarms and control actions derived from analog input signals, use adjustable time delays and deadbands.

2. For alarms and control actions derived from discrete input signals, use adjustable time delays.

3. Initial settings for time delays shall be 10 seconds (range 0-120 seconds). Initial settings for deadbands shall be 5% of span (range 0-100%).

4. Equipment that is started or stopped manually by the operator shall start or stop immediately, with no time delay.

C. Unless otherwise indicated, all setpoint control shall be by PID control algorithms. Where only proportional control is specified, tuning constants shall be used to reduce the Integral and Derivative functions to zero. All setpoints, sequence times, sequence orders, dead bands, PID tuning parameters, PLC delay timers, variable speed operating range limits, and similar control constants shall be accessible and alterable from the operator workstations.

D. Unless otherwise specified, all equipment shall automatically restart after a power failure utilizing adjustable start delay timers in PLC control logic. Unless otherwise specified, all PLC control strategies shall be based upon automatic restart after a power failure and shall return to a normal control mode upon restoration of power.

E. The PLC shall be capable of receiving initial run-time values for existing and proposed equipment. Initial run-time shall not automatically be assumed to be zero.

F. A control discrepancy alarm shall be generated through the PLC for any drive, motor, etc. for which a command has been issued, but for which the PLC is not receiving a confirming status signal (e.g., start command with no run feedback). The failure shall be logged.

G. An instrument failure alarm shall be generated for any instrument which is generating a signal that is less than 4 mA or greater than 20 mA.

H. Unless otherwise specified in an individual control description, an instrument failure or control discrepancy alarm shall cause the control strategy to maintain last values and to generate an alarm. Manual initiation of the automatic control strategy shall be required.

I. A control program that controls multiple pieces of equipment shall not be prevented from running because not all of the equipment is in AUTO. If equipment within an equipment chain is required to be running for program operation and it is running in HAND or MANUAL, then the program shall run and control the other equipment that is in AUTO.

J. All PLC wait states (internal time delays, etc.) after an operator action shall be displayed on the operator workstation.

PART 3 -- FUNCTIONAL CONTROL DESCRIPTIONS

PART 3 – TABLE OF CONTENTS	

3.01 AERATION SYSTEM

A. Process Overview

1. PLC-10 shall provide for dissolved oxygen (D.O.) and air flow monitoring in the Aeration Tanks and provide for control of the D.O. control valves based on maintaining an air flow setpoint. PLC-10 shall also monitor system pressure on the blower discharge piping and provide automatic blower inlet throttling valve control signals to the blower factory control panels (FCPs). PLC-10 shall also provide for blower monitoring, automatic starting/stopping and remote-manual starting/stopping of the blowers through network communication with the blower FCPs. The aeration system shall be controlled as described in the functional descriptions that follow.

2. Aeration system control programs shall operate independently and shall include the following aeration control functions:

a. Blower monitoring;
b. Blower start-up and shutdown programs;
c. Monitoring of blower discharge air header pressure and temperature;
d. Monitoring of total system air flow;
e. Dissolved oxygen monitoring;
f. Air flow control valve position;
g. Inlet throttling valve position;
h. Control of blower above minimum horsepower with one blower in operation;
i. Control program for initiation of a blower start-up with one, two or three blowers in operation;
j. Control program for initiation of a blower shutdown with two, three or four blowers in operation;
k. Aeration Basin effluent monitoring.

B. Control Equipment

1. Air flow meters and motor operated valves to distribute air are summarized as follows:

Air Flow Meter	Motor Operated Valve	Service
FE/PDIT-2121	MOV-2121	Aeration Tank 1 – West Side
FE/PDIT-2122	MOV-2122	Aeration Tank 1 – East Side
FE/PDIT-2221	MOV-2221	Aeration Tank 2 – West Side
FE/PDIT-2222	MOV-2222	Aeration Tank 2 – East Side

2. The dissolved oxygen probes and indicating transmitters in the activated sludge facilities are listed as follows:

Dissolved Oxygen Instrumentation	Service
AE/AIT-2141	Aeration Tank 1 – West Side
AE/AIT-2142	Aeration Tank 1 - East Side
AE/AIT-2241	Aeration Tank 2 – West Side
AE/AIT-2242	Aeration Tank 2 – East Side

3. The blower system shall consist of four multi-stage centrifugal blowers; two large blowers with 600-horsepower motors, and two small blowers with 400-horsepower motors. The capacity of each blower shall be controlled through modulating inlet throttling valves.

4. One pressure transmitter (PIT-1500) and temperature transmitter (TIT-1500) shall be provided on the blower discharge for calculating scfm airflow.

5. The existing Aeration Basin effluent multi-parameter analyzer (AE/AIT-2550) shall be connected to the Plant SCADA system to provide monitoring and trending of Aeration Basin effluent ammonia, nitrate and MLSS concentration.

C. Control Operation

1. Analog input data from field instruments for the aeration system control programs shall be connected to PLC-10 and continuously trended in the Plant SCADA system. All inputs and outputs for the aeration system control programs shall be connected to PLC-10. Aeration system control programs shall reside in PLC-10 located in the new Blower Electrical Power Center with monitoring and control provided through the Plant SCADA system.

2. Blower Monitoring

   a. Blower monitoring and protection from abnormal operating conditions shall be provided through the individual blower factory control panels (FCPs). Status and alarm information and values of measured variables for the blowers shall be provided by the individual blower FCPs to PLC-10 via Ethernet.

3. Blower Start-up and Shutdown Controls

   a. Blower start-up and shutdown controls shall be provided at blower FCPs. Each of the blowers shall be capable of being started or stopped:

      i. Manually at the blower FCP

      ii. Manually through the Plant SCADA system (Remote-Manual)

      iii. Automatically through the Plant SCADA System

b. The Plant SCADA system shall indicate an alarm message that manual start-up of a blower is required, noting the blowers that were last running and the blower designated for starting in Step 1 of the step sequence program, after a power failure or after all blowers are out of service.

i. When all blowers are out of service, PLC-10 shall discontinue automatic air flow control and inlet throttling valve control functions until the subsequent blower start-up sequence is completed.

4. Monitoring of Blower Discharge Air Header Pressure and Temperature

a. The Instrumentation Subcontractor shall provide programming for monitoring aeration system header pressure from the pressure transmitter (PIT-1500) on the blower discharge piping.

b. The Instrumentation Subcontractor shall provide programming for monitoring aeration system temperature from the temperature transmitter (TIT-1500) on the blower discharge piping.

5. Monitoring of Total System Air Flow

a. The Instrumentation Subcontractor shall provide programming for calculating air flows based on differential pressure measurements through four (4) insert flow tubes for measuring air flows to the Aeration Tanks. Individual air flows through each flow tube shall be calculated based on the form of the equation in Specification Section 17610 – Insert Venturi Flow Tubes. Air flows shall be calculated in SCFM based on differential pressure signals from the respective flow tubes and from the pressure and temperature measurements on the blower discharge piping.

b. Total system airflow shall be calculated, monitored, and logged in the Plant SCADA system based on the sum of airflows from the following transmitters:

Total System Airflow = FE/PDIT-2121 + FE/PDIT-2122 + FE/PDIT-2221 + FE/PDIT-2222

6. Dissolved Oxygen Monitoring

a. Independent control programs shall be provided by the instrumentation subcontractor in the Plant SCADA system for monitoring the dissolved oxygen concentrations in each aeration control zone. Two dissolved oxygen sensors and indicating transmitters shall be provided in each Aeration Tank (four total) for monitoring dissolved oxygen concentrations. Adjustments to the aeration control valves in response to the D.O. concentrations shall be entered manually through the Plant SCADA system.

b. The Plant SCADA system shall provide an alarm if measured D.O. concentrations decrease below or increase above setpoint values. A program display shall be provided for selecting minimum and maximum D.O. concentrations with initial setting as follows:

Control Zone	DO Analyzer	Low D.O. Alarm Setpoint	High D.O. Alarm Setpoint
Aeration Tank - West Side	AE/AIT-2141	0.5	3.0
Aeration Tank 1 - East Side	AE/AIT-2142	0.5	3.0
Aeration Tank 2 - West Side	AE/AIT-2241	1.0	3.0
Aeration Tank 2 - East Side	AE/AIT-2242	1.0	3.0

c. If any of the D.O. signals are outside alarm limits (above 6 mg/l or less than 0.3 mg/l, adjustable), an "D.O. signal out of range" alarm shall be produced and displayed through the plant SCADA system.

7. Air Flow Control Valve Position Control

a. Independent analog outputs shall be provided by the Instrumentation Subcontractor in PLC-10 for each of the air flow control valves. The minimum time increment between control corrections and % of each increase and decrease of the analog output signal shall be selectable through the programming display as specified. These tuning constants shall be field-adjusted for optimum loop stability, speed and response.

b. Increase/decrease analog outputs to each of the air flow control valves shall be controlled by PLC-10 based on maintaining an operator-entered air flow setpoint or through remote-manual adjustment of valve position through SCADA. Under normal conditions, manually entered air flow setpoints shall regulate the positioning of the control valves to maintain the D.O. setpoints. Automatic adjustment of control valves based on air flow shall be able to be enabled or disabled through the programming display.

i. When the air flow is less than the setpoint minus the deadband, then PLC-10 shall increase the position output to the air flow control valve to increase the air flow. When the air flow is within the deadband concentrations, then no correction shall be made.

ii. When the air flow is greater than the set point plus the deadband, then PLC-10 shall decrease the position output to the air flow control valve to decrease the air flow. When the air flow is within the deadband concentrations, then no correction shall be made.

iii. The maximum number of position changes per minute and the % change shall be settable through the programming screen as described above.

iv. The magnitude of each correction and the number of corrections per minute shall be adjustable through the program screen.

v. The magnitude of each correction and the number of corrections per minute shall be adjusted during start-up to provide stable and reliable automatic control.

vi. The system shall be controlled such that all valves are corrected at the same time.

c. The operator shall also be able to manually adjust the valve position by entering a percentage open through the Plant SCADA system.

d. Programming shall be provided for clamping minimum and/or maximum positions of the air flow control valves. Clamping control shall be able to be enabled and disabled, and minimum and maximum clamp settings shall be adjustable for each zone. Initial clamps shall be as follows:

Control Zone	Air Flow Control Valve	Minimum Position Clamp	Maximum Position Clamp
Aeration Tank 1 - West Side	MOV-2121	0%	80%
Aeration Tank 1 - East Side	MOV-2122	0%	80%
Aeration Tank 2 - West Side	MOV-2221	20%	100%
Aeration Tank 2 - East Side	MOV-2222	20%	100%

e. The Plant SCADA system shall provide an alarm that the measured or operator-entered air flow has decreased below the minimum air flow required to ensure proper air distribution through the diffuser or has increased above the maximum air flow allowable to limit diffuser flux. The programming display shall allow for modification of the setpoints for minimum and maximum air flow alarms. Initial setpoints shall be as follows:

Control Zone	Air Flow Control Valve	Corresponding Flow Tube	Minimum Air Flow Setpoint	Maximum Air Flow Setpoint
Aeration Tank 1 - West Side	MOV-2121	FE/PDIT-2121	1,130	6,780
Aeration Tank 1 - East Side	MOV-2122	FE/PDIT-2122	1,130	6,780
Aeration Tank 2 - West Side	MOV-2221	FE/PDIT-2221	1,780	10,700
Aeration Tank 2 - East Side	MOV-2222	FE/PDIT-2222	1,780	10,700

8. Inlet Throttling Valve Position Program

a. The blower inlet throttling valve control programs shall be provided by the instrumentation subcontractor in the Plant SCADA system and shall increase or decrease the position of the inlet throttling valves for the operating blowers based on the pressure in the air header.

b. Different pressure setpoints shall be used according to the number of blowers in service as indicated in the description of programming displays. Pressures shall be adjustable over the ranges indicated.

c. Input to the inlet throttling valve control programs shall be the header pressure from the pressure transmitter (PIT-1500) on the blower discharge piping averaged over an operator selectable time period.

d. The Plant SCADA system shall send a signal to the respective blower(s) FCP to increase or decrease the position of the inlet throttling valve. The Plant SCADA system shall track inlet throttling valve position (as a percent open) based on feedback from the blower FCPs.

   i. When the pressure is less than the setpoint minus the deadband, PLC-10 shall provide a fixed “increase” correction consisting of percentage of valve opening through an analog command communicated to the blower via Ethernet.

   ii. When the pressure is more than the setpoint plus the deadband, PLC-10 shall provide a fixed “decrease” correction consisting of percentage of valve opening through an analog command communicated to the blower via Ethernet.

   iii. The magnitude of correction shall be adjustable through the program screen.

   iv. The number of corrections per minute shall be adjustable through the program screen.

   v. The magnitude of each correction and the number of corrections per minute shall be adjusted during start-up to provide stable and reliable automatic control.

e. Operating blowers shall be controlled at the same horsepower by the Plant SCADA system. Controls shall be provided for correction of deviations of inlet valve position to maintain equal horsepower among operating blowers of similar capacity such that horsepower for any operating blower is not more than 2% (1 to 5%) from the average horsepower. This correction will occur only during normal modulating operations and will consist of increase throttling valve position corrections for the blower(s) as required. Such corrections will be above and beyond the number and frequency of corrections selected in programming displays. The operator shall be able to manually adjust the inlet valve position through the Plant SCADA system when the blowers are operating in the Remote-Manual and Automatic modes. The operator shall be able to input a percentage (50% to 100%) of the operating range of each blower.

f. The Instrumentation Subcontractor shall provide adjustable setpoints for header pressure according to the number of blowers in operation as follows:

Number of Blowers in Operation	Initial Setpoint Pressure (psig)	Range (psig)
1	6.0	5.5 – 7.5
2	6.2	5.5 – 7.5
3	6.5	5.5 – 7.5
4	6.8	5.5 – 7.5

9. Control of Blowers Above Surge with One Blower in Operation Control Program

a. A control program shall be provided by the Instrumentation Subcontractor for preventing automatic controls from forcing a blower into a surge condition with one blower in operation. The program shall prevent automatic controls from forcing a single operating blower into surge based on horsepower or position of the inlet throttling valve. The use of horsepower or inlet valve position for controlling a single blower above surge shall be selectable through the program display. The decrease position signals to the inlet throttling valves and dissolved oxygen/airflow control valves shall be disabled under minimum horsepower or minimum inlet throttling valve position conditions.

When horsepower is selected for controlling a single blower above surge, decrease signals to the inlet throttling valve and airflow control valves shall be disabled when the horsepower is less than the setpoint horsepower for that blower. Initial settings shall be 225 horsepower for each of the two 400-horsepower blowers and 350 horsepower for the 600-horsepower blower and shall be confirmed by the Instrumentation Subcontractor with the bower manufacturer. Position decrease signals shall be enabled again when airflow required by the process results in an increase in horsepower above the setpoint.

When inlet throttling valve position is selected for controlling a single blower above surge, decrease signals to the inlet throttling valve and airflow control valves shall be disabled when the inlet throttling valve position is less than the minimum selected in the program display. Position decrease signals shall be enabled again when airflow required by the process results in the opening of the inlet throttling valve.

10. Control Program for Initiation of the Blower Start-Up Sequence with One, Two or Three Blowers in Operation

a. The Instrumentation Subcontractor shall provide an independent control program in PLC-10 for initiation of the blower start-up sequence with one, two, or three blowers in operation. A programming screen shall be provided for selecting fully automatic starting, plant control system prompt alarm for manual start/stop, and off program for each of the blowers as specified.

b. A step program and alternation program shall be provided in PLC-10 that shall assign operating blowers to provide increasing air flow as the process requires. The program shall be used to control starting and stopping when blowers are controlled fully automatically and shall be used to generate alarm messages that selected blowers should be started and stopped manually when blowers are in the Prompt/Manual Mode. Initial settings shall be as shown in the description of programming screens.

i. For the alternation program, when a blower starts up, it shall become the lead blower, and remaining blower(s) online shall be the lag blowers. When a blower shuts down, it shall go to the end of the queue. The goal of the alternation program is to equalize the runtime on all of the blowers.

c. PLC-10 shall monitor the inlet throttling valve position and blower horsepower to determine when a blower start-up sequence is required as described in the description of program screens.

d. A start-up sequence shall be determined to be required by PLC-10 when the inlet throttling valve position of an operating blower reaches 100% or when the horsepower for any operating blower reaches the impending overload setting of 400 horsepower for the 400-horsepower blowers and 600 horsepower for the 600-horsepower blowers.

e. PLC-10 shall initiate a blower start-up sequence when blowers are started fully automatically (or report that a start-up sequence is required when blowers are in the Prompt/Manual Start/Stop Mode) after an independent adjustable time delay.

i. The timer shall start timing when the inlet throttling valve on any operating blower is at “100%” open position or when horsepower of any operating blower reaches the horsepower setting for impending overload and discharge header pressure is less than the setpoint value.

ii. The timer shall continue timing as long as an operating blower is at 100% of maximum throttling valve position or horsepower. The timer shall stop timing and reset if any blowers are operating at less than 100% position or horsepower.

iii. This time delay shall be adjustable through the programming displays and shall be initially set for 10 minutes.

iv. When the delay timer times out, PLC-10 shall automatically initiate the start-up sequence when blowers are started fully automatically (or report that a start-up sequence is required when blowers are in the Prompt/Manual Start/Stop Mode) and shall provide an alarm message of which blowers should be started and stopped according to the step program assignment.

v. It shall be possible to manually initiate a blower start-up sequence from the graphic screen or Operator's keyboard.

f. PLC-10 shall not allow more than one blower to be started in an adjustable time period (initial setting of 15 minutes) under any conditions except when there are multiple failures of blowers to be started and shall not initiate start-up of sequence for any single blower more than once in any adjustable time period (initial setting of 30 minutes) as described in the programming display.

g. When PLC-10 automatically initiates a blower start-up sequence (or when the start-up sequence is manually initiated), the program shall disable all airflow control valves and inlet throttling valve position control programs for all operating blowers and shall position inlet throttling valves on all operating blowers to the start position as described in the programming displays. The Instrumentation Subcontractor shall coordinate with the blower manufacturer for the manufacturer-recommended position of inlet throttling valve on operating blowers when a second, third or fourth blower is being started.

h. PLC-10 shall monitor elapsed time after initiating a blower start-up sequence. Failure to complete the start-up sequence as sensed by the blower not running after an adjustable period as described in the program displays shall generate a start-up sequence failure alarm message. After the start-up sequence failure, the program shall initiate a start-up sequence (when in Automatic Mode) or report that manual start-up is required (when in Remote-Manual Mode) for the next blower in the step program. After a successful start-up, the program shall re-establish airflow valve and inlet throttling valve position control.

11. Control Program for Initiation of the Blower Shutdown Sequence with Two, Three or Four Blowers in Operation

a. The Instrumentation Subcontractor shall provide an independent control program in PLC-10 for initiation of the shutdown sequence with two, three, or four blowers in operation.

i. The programming screen described for selecting fully automatic starting/stopping, for prompt of Manual Start/Stop and for off program shall determine how blowers shall be shut down.

ii. As described above, the program shall be used to control starting and stopping when blowers are controlled fully automatically and shall be used to generate alarm messages that selected blowers should be started and stopped manually when blowers are in the Prompt/Manual Mode.

iii. The program shall not automatically shut down a single blower in operation.

b. PLC-10 shall monitor the blowers to determine when a blower shutdown sequence is required. PLC-10 shall monitor inlet throttling valve position and horsepower of the operating blowers and shall monitor total system air flow to determine when a blower shutdown sequence is required.

c. Independent control programs shall be provided for disabling air flow control valve and blower throttling valve decrease signals to all operating blowers when two, three, or four blowers are in service and when the inlet throttling valve position or motor horsepower decreases below the lower limit.

d. A shutdown sequence shall be determined to be required when total system air flow decreases below the lower limit setpoint assigned in the programming screen for that step in the program or when the inlet valve position or horsepower of any blower decreases below the lower limit.

i. The timer shall start timing when total system airflow or throttling valve position or horsepower for any operating blower decreases below the lower limit.

ii. The timer shall stop timing and reset when total system air flow or throttling valve position or horsepower for any operating blower increases above their lower setpoint limits.

iii. The initial setting for this timer shall be 10 minutes and shall be adjustable through the programming screen.

iv. When the delay timer times out, PLC-10 shall automatically initiate the shutdown sequence when blowers are stopped fully automatically (or report that a shutdown sequence is required).

v. It shall be possible to manually initiate a blower shutdown sequence from the graphic screen or Operator's keyboard.

e. PLC-10 shall select blower(s) to be shut down for initiation of the shutdown sequence (or prompting of manual shutdown) based on the step program and alternation program.

f. PLC-10 shall begin timing after automatically initiating a blower shutdown sequence. Failure of the blower to shut down within 30 seconds (adjustable 0-120 seconds) shall generate a shutdown sequence failure alarm and shall maintain status of the step program until the alarm is acknowledged and the appropriate blower(s) is shut down.

12. Aeration Basin Effluent Monitoring

a. The Instrumentation Subcontractor shall provide an independent control program in PLC-10 for monitoring, trending and data logging of Aeration Basin effluent ammonia, nitrate and MLSS from the existing YSI/WTW multi-parameter analyzer (AE/AIT-2550).

D. Programming and Graphic Displays

1. Programming screens for the aeration system control programs shall be provided for a selection of control modes and control settings.

2. A program display shall be provided for selecting fully automatic starting/stopping, prompting for manual start/stop, or off program for each of the four blowers as shown below (initial settings shall be as noted).

		SCFM	Fully Automatic Starting/Stopping	Prompt for Manual Start/Stop	Off Program
Blower 1		7,400	X		
Blower 2		7,400	X		
Blower 3		11,100	X		
Blower 4		11,100	X		

3. A step program shall be provided in PLC-10 for turning blowers on and off to best match process requirements. The program shall allow for operator input of blower availability and step assignment with initial settings as follows:

	Blower 1 (7,400 scfm)	Blower 2 (7,400 scfm)	Blower 3 (11,100 scfm)	Blower 4 (11,100 scfm)
Step 1	X			
Step 2			X	
Step 3	X		X	
Step 4			X	X
Step 5	X		X	X
Step 6	X	X	X	X

a. The Instrumentation Subcontractor shall modify step assignments during installation as required for the blowers furnished.

b. An alternation program shall be provided that will automatically alternate blowers of the same capacity to equalize run time.

c. When a blower fails, the plant control system shall automatically start another blower when in fully automatic mode. If a blower fails and no other blower is available for starting, then the plant control system shall display an alarm through SCADA.

d. The graphic display shall show a blower as being “unavailable” when the blower is selected to be “Off Program” and shall be deleted from the step program when selected to be “Off Program”.

e. Total air flow, horsepower, or inlet valve position shall be the basis for determining when the step program is decreased one step. Initial settings for the lower limit of air flow, horsepower and speed for each step shall be as follows:

	Number of Small Blowers Operating	Number of Large Blowers Operating	Total Air Flow Lower Limit (scfm)	Blower Horsepower Lower Limit (Hp)	Blower Inlet Valve Lower Limit (% open)
Step 2	0	1	6,500	Disabled	Disabled
Step 3	1	1	10,500	Disabled	Disabled
Step 4	0	2	18,000	Disabled	Disabled
Step 5	1	2	21,500	Disabled	Disabled
Step 6	2	2	29,000	Disabled	Disabled

f. Blower operating horsepower or inlet valve position shall be the basis for determining when the step programs should be increased one step. If the horsepower or inlet valve position of any operating blower reaches the maximum horsepower or valve position setpoint, and the subsequent time delay occurs, then the program will advance to the next step. Initial settings for maximum blower horsepower and speed setpoints are as follows:

	Horsepower Upper Limit (Horsepower)[1]	Inlet Valve Upper Limit (%)[1]
Blower 1	400	100
Blower 2	400	100
Blower 3	600	100
Blower 4	600	100

4. A program display to select the maximum number of blowers that may be operated as follows (initial setting shall be as noted):

	1	2	3	4
Maximum number of blowers allowed to operate at one time				X

5. Start-up and shutdown sequences for blowers shall be initiated automatically or prompted for manual initiation through programming furnished by the Instrumentation Subcontractor.

6. For automatic starting of blowers or when manually initiating a blower start-up sequence, the plant control system shall discontinue inlet throttling valve control for all operating blowers and shall adjust inlet valve position to the start position. A program display shall be provided for selecting the blower "start" inlet valve position on the operating blowers and on the blower to be started as follows (initial settings shall be as required by the blower manufacturer):

	Operating Blowers	Blower To Be Started
Inlet Valve Start Position (% open)	As required by the blower manufacturer	As required by the blower manufacturer

7. For automatic starting and stopping of blowers through the plant control system, when a condition occurs that calls for a second, third, or fourth blower to start or stop, the plant control system shall wait 15 minutes (adjustable 0-120 minutes) before initiating the called for start-up or shutdown sequence, selectable through the programming screen in the plant control system.

8. The time allowed to complete a start-up sequence and the time allowed to complete a shutdown sequence before the plant control system generates a start-up/shutdown sequence failure alarm shall be adjustable through the programming screen in the plant control system (initial setting = 10 minutes adjustable 0-15 minutes).

9. Timers to limit blower start-ups shall be adjustable through the programming screen in the plant control system. The minimum time between successive start-ups of a single blower shall be 30 minutes (adjustable from 0 to 120 minutes). The minimum time between successive start-ups of any two blowers shall be 15 minutes (adjustable from 0 to 120 minutes).

10. Programming screens in the plant control system shall be provided for timing the airflow and pressure control loops and for selection of setpoints, deadbands, and alarm limits as follows:

Item	**Initial Value (Range)**		
1) Dissolved oxygen input signal alarm limits:	0.3 mg/l low limit (0-10 mg/l) 6 mg/l high limit (0-10 mg/l)		
2) Minimum/Maximum Air Flow Setpoints	See Paragraph C7– "Air Flow Control Valve Position"		
3) Minimum/Maximum Dissolved Oxygen Alarm Setpoints	See Paragraph C6 – "Dissolved Oxygen Monitoring"		
4) Pressure Setpoint	**Condition**	**Setpoint**	**Setpoint Range**
	One blower operating	6.0	5.5 – 7.5
	Two blowers operating	6.2	5.5 – 7.5
	Three blowers operating	6.5	5.5 – 7.5
	Four blowers operating	6.8	5.5 – 7.5
5) Air flow deadband	minus 0 scfm, plus 50 scfm (0-200 scfm)		
6) Pressure deadband	±0.05 psi (0-0.1 psi)		
7) Maximum number of air flow valve corrections per minute	2 (0-20)		
8) Maximum number of blower inlet valve corrections per minute	4 (0-40)		
9) Increment for increase/ decrease inlet valve position signals (coordinate with blower manufacturer)	2% of valve travel (1 to 5)		
10) Duration for rolling average air flow variable.	5 minutes (0 to 15 minutes)		
11) Sample rate for rolling average for D.O. process variable.	10 seconds (1 second to 30 seconds)		

11. HMI graphic screens shall schematically show blowers, bioreactors, and air flow control valves. The graphic screens shall indicate the run status of each blower, alarm conditions for each blower, and show the operating blowers in a different color from the stopped blowers. The screens shall also show the following:
    a. D.O. concentrations in mg/L at each point of measurement.
    b. Minimum and maximum D.O. concentration set points for notification
    c. Air flow rates through each flow meter.
    d. Minimum and maximum airflow set points for notification
    e. Positions of each airflow control valve
    f. Discharge header pressure.
    g. Discharge header pressure set point and deadband.
    h. Total system air flow.
    i. Blower inlet throttling valve position reported by the blower FCP for each blower.
    j. Blower air flow rate reported by the blower FCP for each blower.
    k. Blower inlet temperature reported by the blower FCP for each blower.
    l. Blower discharge temperature reported by the blower FCP for each blower.
    m. Blower inlet filter differential pressure reported by the blower FCP for each blower.
    n. Blower amperage reported by the blower FCP for each blower.
    o. Blower horsepower reported by the blower FCP for each blower.
    p. Current Step in program
    q. Next blower to be started.
    r. Next blower to stopped.
    s. Start-up sequence called for based on inlet valve position or horsepower.
    t. Shutdown sequence called for based on total air flow, inlet valve position or horsepower.
    u. Start-up sequence initiated/in progress/completed.
    v. Shutdown sequence initiated/ in progress/completed.
    w. Blower start-up mode (fully auto, plant control system Prompt/Manual Start/Stop or Off program).
    x. Blower failure alarm reported by the blower FCP for each blower.
    y. Blower FCP communication failure alarm for each blower.
    z. Blower not available for starting.
    aa. Countdown timers
    bb. Aeration basin effluent ammonia concentration
    cc. Aeration basin effluent nitrate concentration

dd. Aeration basin effluent MLSS concentration

3.02 SUBMERSIBLE MIXERS

A. Process Overview

1. Eight (8) submersible mixers (MXR-2131, 2132, 2133, 2134, 2231, 2232, 2233, 2234) shall be provided under Division 11. Four mixers shall be provided in Aeration Tank No. 1 and four mixers shall be provided in Aeration No. 2 to provide mixing of mixed liquor within each tank throughout operation in addition to aeration.

B. Control Equipment

1. Each submersible mixer shall be provided with a local control station (LCS-2131, 2132, 2133, 2134, 2231, 2232, 2233, 2234) under Division 16 and shall include the following:

a. LOCAL-OFF-REMOTE (L-O-R) selector switch

b. E-STOP pushbutton

2. Each submersible mixer shall be manually started and stopped either locally from the local control station or remotely through SCADA. The mixer MCCs shall be equipped with the following for each mixer:

a. IN REMOTE indication light

b. RUN indication light

c. FAIL indication light

C. Control Operation

1. When the submersible mixer LOCAL-OFF-REMOTE (L-O-R) selector switch located at the associated Local Control Station is in the LOCAL position, the mixer shall run continuously. When the L-O-R switch is in the OFF position, the mixer shall not operate under any condition. When the L-O-R switch is in the REMOTE position, the mixer shall be started and stopped manually through SCADA.

3.03 JUNCTION STRUCTURE

A. Process Overview

1. Four (4) motor operated, downward opening slide gates (MOG-2610, 2620, 2630, 2640) shall be installed in the junction structure to control water level and assist in distribution of mixed liquor to final clarifiers. Distribution gates will be positioned manually at local control stations at the valve actuator.

2. Two (2) electrically actuated, emergency bypass sluice gates(MOG-2510, 2520) shall be installed to bypass mixed liquor flows around the distribution weirs during a high-water level condition in the junction structure.

B. Control Equipment

1. Four (4) motor operated, downward opening slide gates (MOG-2610, 2620, 2630, 2640) shall be provided in accordance with Division 15 to maintain a consistent water level in the aeration tanks while providing flexibility for final clarifier distribution.

2. Each electrical actuator shall be provided under Division 15 and shall include:

   a. OPEN-STOP-CLOSE selector switch

   b. Discrete Open/Closed Position and Fault Feedback Signals to PLC

3. Two (2) electrically actuated sluice gates (MOG-2510, 2520) shall be provided under Division 15 to provide emergency bypass flow around the final clarifier distribution weirs during a high-water level condition in the junction structure. Each electrical actuator shall be provided under Division 15 and shall include:

   a. HAND-OFF-REMOTE selector switch

   b. OPEN-STOP-CLOSE selector switch

   c. IN REMOTE status contract to PLC

   d. Analog Position Feedback Signal to PLC

   e. Analog Position Control signal from PLC

4. An ultrasonic level measurement system shall be provided under Division 17 and installed in the junction structure. A level transmitter (LE/LIT-2500) with local indication shall be provided as shown on the drawings to provide continuous level signals to PLC-06.

C. Control Operation

1. The downward opening slide gates (MOG-2610, 2620, 2630, 2640) shall operate in accordance with the local OPEN-STOP-CLOSE selector switch. Open/Closed position feedback shall be provided for each motor operated gate to the PLC for monitoring, but no remote control shall be provided.

2. When the emergency bypass gate HAND-OFF-REMOTE (H-O-R) selector switch located on the gate actuator is in the HAND position, the gate position shall be modulated with the OPEN-STOP-CLOSE selector switch at the actuator. When the H-O-R switch is in the OFF position, the gate shall not operate under any condition. When the H-O-R switch is in the REMOTE position, the gate shall be controlled by the PLC as described below.

3. In the REMOTE mode, the emergency bypass gate actuators (MOG-2510, 2520) shall open if a HIGH level condition in the junction structure is reached and maintained for an adjustable time interval, initially set at 30 seconds. Both

actuators shall open immediately upon a HIGH-HIGH level condition in the Junction Structure. The actuators shall close when the water level in the Junction Structure drops to LOW level. Initial level setpoints are described below:

Action	Range (Elev in feet)	Initial Setpoint
Low Level	111.00 – 112.50	112.50
High Level	112.50 – 113.00	112.75
High-High Level	113.00	113.00

- END OF SECTION -

REPORTS

Terracon GeoReport

BCW&SA WTP Blower Pad
Goose Creek, South Carolina

May 24, 2018

Terracon Project No. EN185113

Prepared for:

Hazen and Sawyer

Mt. Pleasant, South Carolina

Prepared by:

Terracon Consultants, Inc.

North Charleston, South Carolina

Terracon GeoReport

May 24, 2018

Hazen and Sawyer
735 Johnnie Dodds Blvd, Suite 102
Mt. Pleasant, SC 29464

Attn: Ms. Olivia Flynn
Phone: 843-744-6467
Email: oflynn@hazenandsawyer.com

Re: Geotechnical Engineering Services
BCW&SA WTP Blower Pad
Goose Creek, South Carolina
Terracon Project No. EN185113

Dear Ms. Flynn:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number PEN185113 dated April 26, 2018.

This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project and look forward to providing additional Geotechnical Engineering and Construction Materials Testing services in the future. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Leonard Van Brunt, E.I.T
Geotechnical Project Manager

SOUTH CAROLINA
TERRACON
CONSULTANTS, INC.
No. 2220
CERTIFICATE OF AUTHORIZATION

Bryan Shiver
Geotechnical Department Manager
SC Registration No. 27816

SOUTH CAROLINA
LICENSED PROFESSIONAL ENGINEER
5/24/18
No. 27816
BRYAN T. SHIVER

REPORT TOPICS

ATTACHMENTS

GEOTECHNICAL OVERVIEW

This report presents the results of our geotechnical investigation performed for the BCW&SA Blower pad in Goose Creek, South Carolina. Our geotechnical scope of work for this project included conducting geotechnical fieldwork, associated engineering analysis, and this geotechnical engineering report.

This report provides recommendations for foundation options, seismic considerations, site preparation, and the other geotechnical related conditions that might affect the proposed construction. The following geotechnical considerations were identified during our investigation:

- Based on the procedures outlined in IBC 2015 and the results of our field testing, a seismic **Site Class D** will be available for this project. However, the structural engineer should verify that the site class exemption provided by this code is available for the proposed structure.

- We estimate that liquefaction-induced settlements from the design seismic event may range **up to 3 inches** with differential settlement being 50 to 75% of the total. While the project structural engineer should review our estimates, our experience indicates that the liquefaction settlement estimates will not require mitigation.

- Assuming proper site preparation, the structures may be supported on a traditional shallow foundation system bearing on in situ soils or properly compacted Controlled Fill. Total estimated static settlement for traditional shallow and slab foundations is **1 inch or less**, with differential settlement up to **½ inch**.

The recommendations presented herein have been developed on the basis of the subsurface conditions encountered during field investigation and our understanding of the proposed construction. Should changes in the project criteria occur, a review must be made by Terracon to determine if modifications to our recommendations will be required.

GEOTECHNICAL ENGINEERING REPORT
BCW&SA WTP BLOWER PAD
GOOSE CREEK, SOUTH CAROLINA

Terracon Project No. EN185113
May 24, 2018

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the blower pad. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- site preparation and earthwork
- foundation options
- seismic evaluation per IBC
- other geotechnical design parameters

The geotechnical engineering scope of work for this project included the advancement of 1 Seismic Cone Penetration Test (SCPT) to a depth of 69 feet and 1 Cone Penetration Test (CPT) to a depth of 31 feet within the pad footprints. In addition, 1 Dynamic Cone Penetrometer Test (DCP) to a depth of 4 feet within proposed pavement footprint. Adjacent to each test and within the surrounding proposed pad and pavement areas, Hand Auger Borings were performed to depths of 4 feet.

Maps showing the site and testing locations are shown in the **Site Location** and **Exploration Plan** sections, respectively, and logs of the borings are included in the **Exploration Results** section of the ***GeoReport*** site. These sections are included as an appendix to this report.

PROJECT INFORMATION

Our initial understanding of the project was provided in our **Project Understanding** section in the Project Planning stage. During the period of collaboration that has transpired since the project was initiated, our understanding of the project conditions have been modified to reflect the following:

Item	Description
Project location	The project is located at 2111 Red Bank Road in Goose Creek, South Carolina. ■ Latitude: 32.96299° ■ Longitude: -79.94994°
Proposed structure	Blower pad, generator pad, electrical power center pad, architectural precast concrete utility building, and concrete lined pipe trench
Maximum loads	Based on information provided by the client, the following loading conditions were used for our analysis: Architectural Precast Concrete Utility Building ■ Wall: 3 kips per linear feet (klf) ■ Slabs: 150 pounds per square foot (psf) Blower Pad ■ Equipment Weight: 48 kips ■ Dimensions: 56 by 80 feet Electrical Power Center Pad ■ Equipment Weight: 40 kips ■ Dimensions: 25 by 31 feet Generator and Electrical Pads ■ Equipment Weight: 40 kips ■ Dimensions: 15 by 60 feet If final loads or dimensions vary from these assumptions, further review will be necessary.
Grading	Finished floor elevation is unknown. We understand that little to no fill will be required to develop final grade. Final slope angles are not expected to be steeper than 4H:1V (Horizontal: Vertical) are expected.
Pavements	Associated paved driveway and parking will be constructed as part of the project. We have assumed typical 'heavy duty' and 'light duty' traffic loading conditions. We have considered that both rigid (concrete) and flexible (asphalt) pavement sections may be needed.

SITE CONDITIONS

The following description of site conditions is based on our site visit in association with the field exploration.

Item	Description
Site Location	The project is located at 2111 Red Bank Road in Goose Creek, South Carolina. ■ Latitude: 32.96299° ■ Longitude: -79.94994°
Existing improvements	The project site is an existing waste water treatment plant
Current ground cover	Landscaped grass, pavement, and surrounding basins
Existing topography	Existing grades are unknown and a grading plan was not provided. The site appears to be relatively level within project boundaries with less than 1 feet of vertical relief.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Our field exploration services were performed in general accordance with the information provided in our **Planned Exploration and Testing Procedures** in the Project Planning stage of the ***GeoReport***.

Type of Test	Test Location	Number of Tests	Test Depth
Cone Penetration Test (CPT)	New Pad	1	30 feet
Seismic Cone Penetration Test (SCPT)	New Pad	1	50 feet
Dynamic Cone Penetrometer Test (DCP)	New Pavement	1	20 feet
Hand Auger Borings (HABs)	Adjacent to each CPT/DCP	3	4 feet

The approximate location of each test is indicated on the **Exploration Plan**. The test locations were selected by Terracon personnel and located in the field utilizing a commercially available handheld Global Position System (GPS) unit. Dependent on the prevailing weather conditions at the time of boring/sounding layout and overhead power lines these units are typically considered accurate to within ±10 to 20 feet. The locations should be considered accurate only to the degree

implied by the means and methods used to define them. The field exploration was performed on May 11, 2018.

The in situ tests were advanced with a track mounted Pagani TG73-200 rig. Cone Penetration Test soundings were conducted in accordance with ASTM D5778 Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils. Flat Blade Dilatometer Test soundings were conducted in accordance with ASTM D6635 Standard Test Method for Performing the Flat Plate (Blade) Dilatometer.

GEOTECHNICAL MODEL

Subsurface Profile

Based on the results of the field exploration, subsurface conditions on the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum	Material Encountered[1]
Stratum 1	2 feet	Loose to medium dense silty sand
Stratum 2	16 feet	Soft to medium stiff clay with interbedded clayey and sandy silt layers
Stratum 3	24 feet	Soft to stiff clayey silt with interbedded clay seams
Stratum 4	27 feet	Medium dense clean to silty sand
Stratum 5	58 feet	Loose to medium dense sandy silt with interbedded medium stiff to stiff clayey silt layers
Stratum 6	60 feet	Dense clean to silty sand
Stratum 7[2]	69 feet[3]	Medium dense to dense silty sand (Cooper Marl Formation)

1. Material descriptions are based on visual classification from HAB samples and correlations with in situ data.
2. Termination of deepest sounding.
3. The Cooper Marl Formation is a well-studied and uniform soil stratum consisting of clayey to sandy silt approximately 100 to 200 feet thick in the greater Summerville area. This soil stratum is a typical bearing layer for deep foundations as well as the basis for earthquake modeling in the Summerville area. The layers bearing capacity is predominantly derived through skin friction, therefore deep foundation design would include a calculated amount of embedment into the Cooper Marl Formation.

Conditions encountered at each test location are indicated on the individual test records. Stratification boundaries on the test records represent the approximate location of changes in soil types. The transition between materials may be gradual. Details for each of the tests can be found in **Exploration Results**.

Groundwater Conditions

At the time of our exploration, groundwater was encountered at a depth of approximately 8 to 10 feet below the existing ground surface. The ground water depth was determined by physical measure in the voids left by in situ testing and by estimating the hydrostatic line (height of water below the ground surface) on the penetrometer porewater pressure (U) graph in the CPT log. The water levels as observed during field exploration are summarized in the following table and noted on the attached in situ and boring logs, in **Exploration Results**.

Test	Depth to Groundwater within Voids left from Testing (ft)
SCPT-1	10.0
CPT-2	8.0
DCP-1	NE[1]
HAB AT CPT-1	NE
HAB AT CPT-2	NE

1. Not Encountered
2. Not Applicable

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. Fine-grained soils located near the existing ground surface may drain poorly during and after periods of heavy rainfall which caused the possibility for “perched” groundwater conditions during wet months. The groundwater surface should be checked prior to construction to assess its effect on site work and other construction activities.

Groundwater levels were measured using the following criteria:

- Physical observation within hand auger borings (HAB).
- Where not physically encountered in HABs, groundwater levels are measured using a groundwater probe within the voids left by cone penetration (CPT) or flat blade dilatometer (DMT) tests.
- Where not encountered within CPT or DMT voids, groundwater levels are estimated using the hydrostatic line (height of water below the ground surface) on the CPT porewater pressure (U) graph shown on the CPT logs.
- Unless otherwise specified on the logs or in the report, all groundwater measurements are collected during or immediately after drilling.

GEOTECHNICAL SEISMIC CONSIDERATIONS

Seismic Evaluation (Data from USGS)

Code Used	Site Classification
2015 International Building Code (IBC)[1]	D[2]
Seismic Design Parameter	**Value**
F_a	1.00
F_v	1.54
F_{PGA}	1.00
S_{DS}	0.93 g
S_{D1}	0.47 g
PGA_M[3]	0.95 g

1. In general accordance with the 2015 International Building Code and ASCE 7-10 Table 20.3-1, and an average weighted shear wave velocity of 678 feet per second collected from in situ testing methods.
2. Based upon the fundamental period exception outlined in ASCE 7-10 Section 20.3.1
3. Based on procedures outlined in ASCE 7-10 for geotechnical hazards

Liquefaction

Due to the high seismicity of the coastal South Carolina area, we performed a liquefaction potential analysis for the site to evaluate the stability of the subgrade soils. Ground shaking at the foundation of structures and liquefaction of the soil under the foundation are the principle seismic hazards to be considered in design of earthquake-resistant structures. Liquefaction occurs when a rapid buildup in water pressure, caused by the ground motion, pushes sand particles apart, resulting in a loss of strength and later densification as the water pressure dissipates. This loss of strength can cause bearing capacity failure while the densification can cause excessive settlement.

While the amount of settlement is dependent on the magnitude and distance from a seismic event, and geologic age of the soil deposit, we estimate that settlements from the design earthquake may range from **up to 3 inches**. Differential settlement could range up to 50% of the total settlement depending on depth and amount of liquefaction, and location relative to a seismic event epicenter. Design under the IBC allows for buildings to sustain damage during the design earthquake event, but they must remain standing. Therefore, our liquefaction settlement estimate should be reviewed from the standpoint of risk of total collapse of the structure. While the project structural engineer should review our estimates, in our experience, the calculated liquefaction potential does not require mitigation.

SITE PREPARATION CONSIDERATIONS

The initial step in site preparation is to strip the proposed construction area of any underground utilities, topsoil, roots, root balls, organic material, debris, and other deleterious material from within the proposed building footprint and parking areas. Stripping should extend a minimum of 5 feet outside the construction area footprint if site constraints allow. We anticipate stripping depths to average up to 4 inches across the site. Voids remaining from the clearing/stripping operation should be backfilled with properly compacted Controlled Fill.

After stripping and subgrade repair is completed, the existing subgrade should be proofrolled with a loaded tandem axle dump truck or other similar approved construction equipment if site constraints allow. A geotechnical engineer should monitor proofrolling operations. Areas that pump or rut excessively should be undercut and reworked or replaced with Controlled Fill. Due to the presence of near surface clays and shallow ground water, instability will be encountered during subgrade preparation. It is likely that much of this unstable material will require undercutting and replacement and/or chemical treatment with lime or cement. Construction budgets should have contingencies for undercutting and replacement and/or chemical treatment. Terracon can help with estimating quantities upon request. The project site should be graded to promote drainage and direct stormwater runoff away both during construction and the operational life of the structures. Fill placement may commence after the subgrade stability has been verified by the geotechnical engineer.

Due to shallow groundwater depths and near surface clays, control of groundwater and surface runoff will be an important aspect of site preparation. We recommend an overall site drainage plan be implemented prior to rough grading operations. This plan can consist of a series of ditches tied to sumps. The ditches can be constructed along the outer perimeter of the site, internal to the site, or in other areas dictated by the natural topography. Sumps should be pumped to remove water to appropriate detention areas. Terracon can assist in determining an appropriate drainage plan once grading plans are complete.

We understand that there will be a concrete-lined utility trench installed on the project site and that shallow excavations will be required. Excavations for utilities should be performed according to the pipe manufacture's recommendations. Backfill for the excavation should consist of properly compacted Controlled Fill as described in material types. Excavations and backfilling should be conducted prior to slab or pavement installation.

Material Types

If onsite soils are used as fill they should meet the requirements outlined below. Controlled fill should meet the following soil property requirements:

Fill Type[1]	USCS Classification	Acceptable Location for Placement
Controlled/Imported Fill	SP, SP-SM, SP-SW, SW (Passing #200<12%)	All locations
Onsite Soil	SP, SP-SM, SP-SC, SM (Passing #200<25%)	All locations

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and other deleterious debris.

Compaction Requirements

ITEM	DESCRIPTION
Fill Lift Thickness	When heavy, self-propelled compaction equipment is used, fill lifts shall have a maximum of 10 inches in loose thickness.
	When hand-guided equipment (i.e. jumping jack or plate compactor) is used, fill lifts shall have a maximum of 2 to 4 inches in loose thickness.
Compaction Requirements[1]	The upper 12 inches of the floor slab subgrade should be compacted to 100% of the material's maximum Modified Proctor dry density (ASTM D1557).
	Graded Aggregate Base Course (GABC) below pavements should be compacted to 100% of the material's maximum Modified Proctor dry density (ASTM D1557).
	Other structural areas should be compacted to 95% of the material's maximum Modified Proctor dry density (ASTM D1557).
Moisture Content – Controlled Fill or Onsite Soils[2]	Within the range of ±2% of optimum moisture content value as determined by the Modified Proctor test.

1. Fill should be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the Controlled Fill material pumping when proofrolled.

Backfill Construction Observation and Testing

The exposed subgrade and each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the geotechnical engineer's representative prior to placement of additional lifts. We recommend that each lift of fill be tested for density and moisture content at a

frequency of one test for every 5,000 square feet in pavement areas and every 2,500 square feet for building areas. We recommend one density and moisture content test for every 50 linear feet of compacted utility trench backfill.

Earthwork Construction Considerations

It is anticipated that shallow excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Upon completion of filling/cutting and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction and observed by Terracon.

Surface water should not be allowed to pond on the site and soak into the soil during construction. Construction staging should provide drainage of surface water and precipitation away from the building areas. Any water that collects over or adjacent to construction areas should be promptly removed, along with any softened or disturbed soils. Surface water control in the form of sloping surfaces, drainage ditches and trenches, and sump pits and pumps will be important to avoid ponding and associated delays due to precipitation and seepage.

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proofrolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

FOUNDATION RECOMMENDATIONS

Assuming the successful implementation of proper site preparation, our analysis indicated that the pads can likely be supported using a slab on grade. Design recommendations for the slab on grade for the proposed structures and equipment are presented in the following paragraphs.

Design Recommendations

Description	Blower Pad	Generator Pad and Sound Enclosure	Electrical Power Center	Architectural Precast Concrete Utility Building
Allowable bearing pressure[1]	350 psf	350 psf	350 psf	2000 psf
Minimum embedment below finished grade	NA	NA	NA	12 inches
Estimated total static settlement[2]	1 inch or less	1 inch or less	1 inch or less	1 inch or less
Estimated differential static settlement	< ½ inch between footing and slab	< ½ inch between footing and slab	< ½ inch between footing and slab	< ½ inch over 30 feet

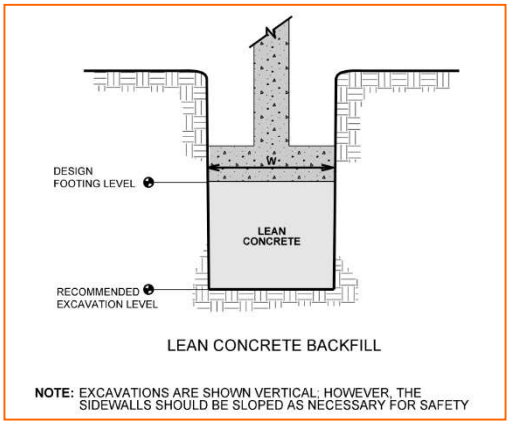
1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This assumes that any unsuitable fill, debris or soft soils, if encountered, will be undercut and replaced with Controlled Fill.
2. The precast concrete utility building settlement estimates are based on a maximum load of 3 kips per foot for strip footings and the above allowable bearing pressure. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth, and dimensions of the footings, the thickness of compacted fill, and the quality of earthwork operations. These settlement calculations were based on maximum footing size of 3 ft wide strip footings.
3. The settlement estimates for slabs on grade are based on the following loading conditions:
   - Generator Pad and Sound Enclosure with a load of 40 kips and a 15 by 60 foot slab on grade
   - Electrical power center with a load of 40 kips and a 25 by 31 foot slab on grade
   - Blower Pad with a load of 48 kips and a 56 by 80 foot slab on grade

   Should slab loading conditions or slab dimensions differ from these listed above, a review must be made by Terracon personnel in order to affirm or modify the above estimates

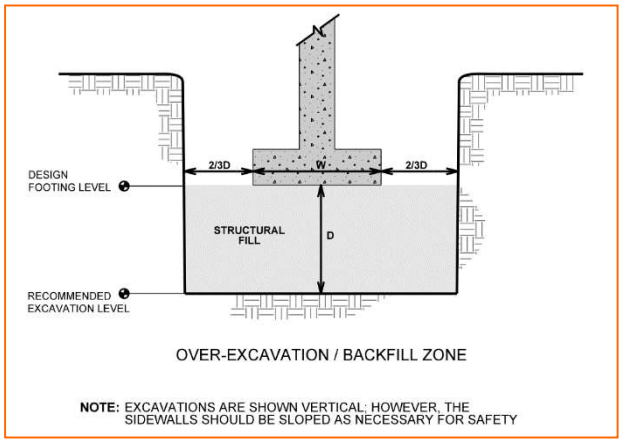
Shallow Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.



Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with controlled fill placed, as recommended in the **Earthwork** section.



FLOOR SLABS

Floor slabs can be supported by properly compacted Control Fill if prepared as described in the **Earthwork** section of this report. The concrete floor slab constructed on grade can be designed using the modulus of subgrade reaction presented in the following table.

Item	Description
Floor slab support [1]	200 pounds per square inch per inch (psi/in) for point loading conditions [2]

1. Floor slabs should be structurally independent of any building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

Floor slab subgrade should be compacted to 100% of its Modified Proctor maximum dry density (ASTM D1557). If chemically treated soils are being placed beneath the floor slab, the treatment process should be closely monitored by the geotechnical engineer to ensure that the soils are not over-treated with cement. The structural engineer should design the floor slab to limit differential movements between the slab and foundation to reduce the possibility of floor slab cracking. Where appropriate, saw-cut control joints and expansion joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

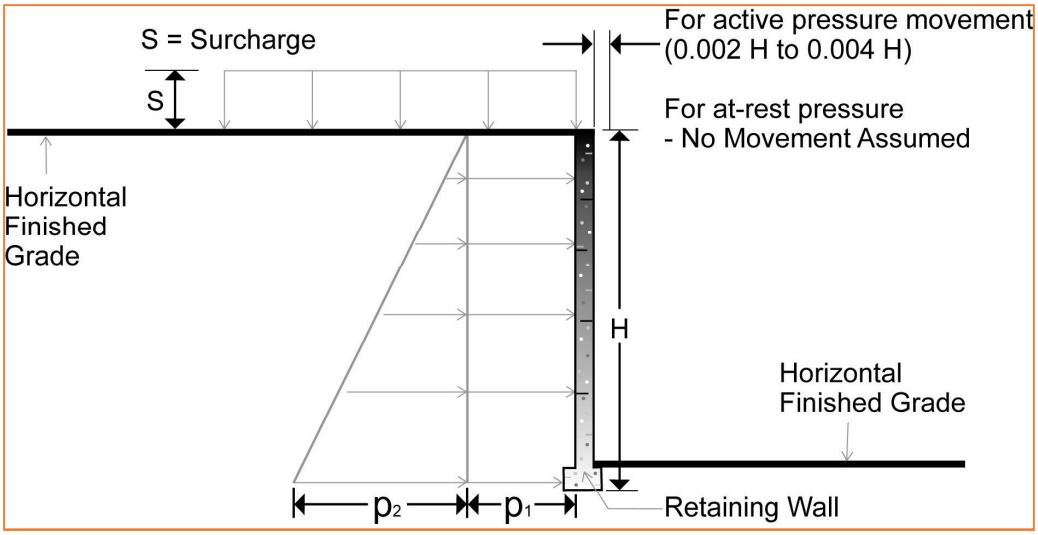
Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or any cracks that develop should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

CONCRETE-LINED UTILITY TRENCH

We understand that excavations will be required for the concrete-lined utility trench. The following design parameters should be considered for excavations.

Design Parameters

Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Earth Pressure Coefficients

Earth Pressure Conditions	Coefficient for Backfill/Soil Type	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (Ka)	Controlled Fill - 0.33	40	(0.33)S	(40)H
	Stratum 1 – 0.33	35	(0.33)S	(36)H
	Stratum 2 – 1.0	90	(1.0)S	(90)H
At-Rest (Ko)	Controlled Fill - 0.5	60	(0.5)S	(60)H
	Stratum 1 – 0.5	53	(0.5)S	(55)H
	Stratum 2 – 1.0	90	(1.0)S	(90)H
Passive (Kp)	Controlled Fill – 3.0	360	---	---
	Stratum 1 – 3.0	330	---	---
	Stratum 2 – 1.0	90	---	---

Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 **H** to 0.004 **H**, where **H** is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight of 120 pcf
- Horizontal backfill, compacted to 95 percent of modified Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included

Backfill placed against structures and/or the trench should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, a value of 0.32 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

GENERAL COMMENTS

Our work is conducted with the understanding of the project as described in the proposal, and will incorporate collaboration with the design team prior to completing our services. Terracon has requested verification of all stated assumptions. Revision of our understanding to reflect actual conditions important to our work will be based on these verifications and will be reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions. The design team should also collaborate with Terracon to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations.

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from the site exploration performed and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. So, Terracon should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for that specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. In the event that changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION

BCW&SA WTP Blowers ■ Goose Creek, SC
May 23, 2018 ■ Terracon Project No. EN185113

Terracon GeoReport

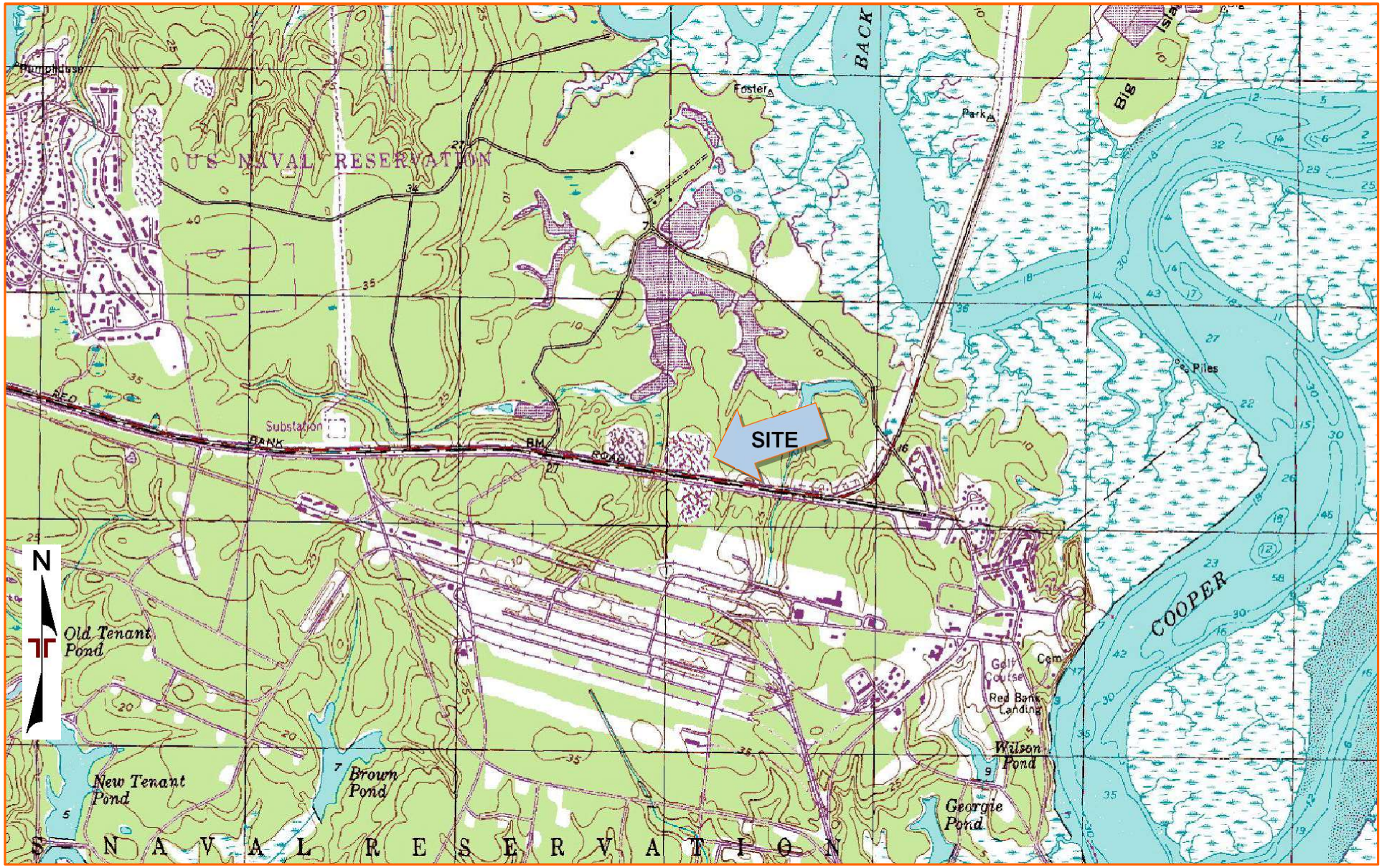


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: NORTH CHARLESTON, SC (1/1/1998).

EXPLORATION PLAN

BCW&SA WTP Blowers ■ Goose Creek, SC
May 23, 2018 ■ Terracon Project No. EN185113

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

IN SITU TEST RESULTS

CPT LOG NO. CPT-2

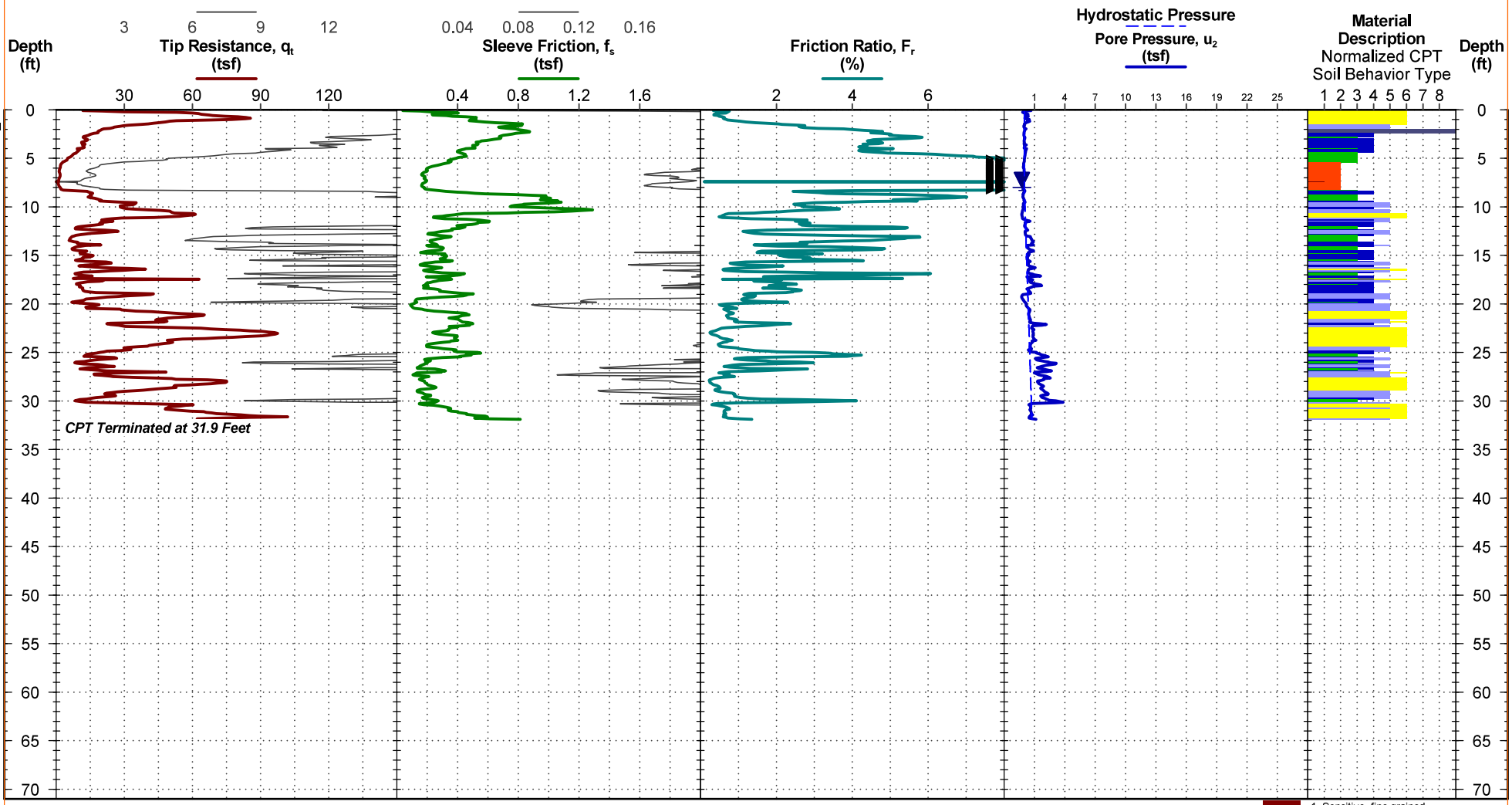
PROJECT: BCW&SA WTP Blowers

CLIENT: Hazen and Sawyer PC
Mt. Pleasant, SC

TEST LOCATION: See Exploration Plan

SITE: 2111 Red Bank Rd
Goose Creek, SC

Latitude: 32.9629°
Longitude: -79.9504°



CPT sensor calibration reports available upon request.

WATER LEVEL OBSERVATION

8 ft estimated water depth
(used in normalizations and correlations)

Probe no. 4986 with net area ratio of 0.865
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 10/3/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 Fifth St W
North Charleston, SC

CPT Started: 5/11/2018
CPT Completed: 5/11/2018
Rig: Pagani TG73-200
Operator: B. Rozier
Project No.: EN185113

CPT LOG NO. SCPT-1

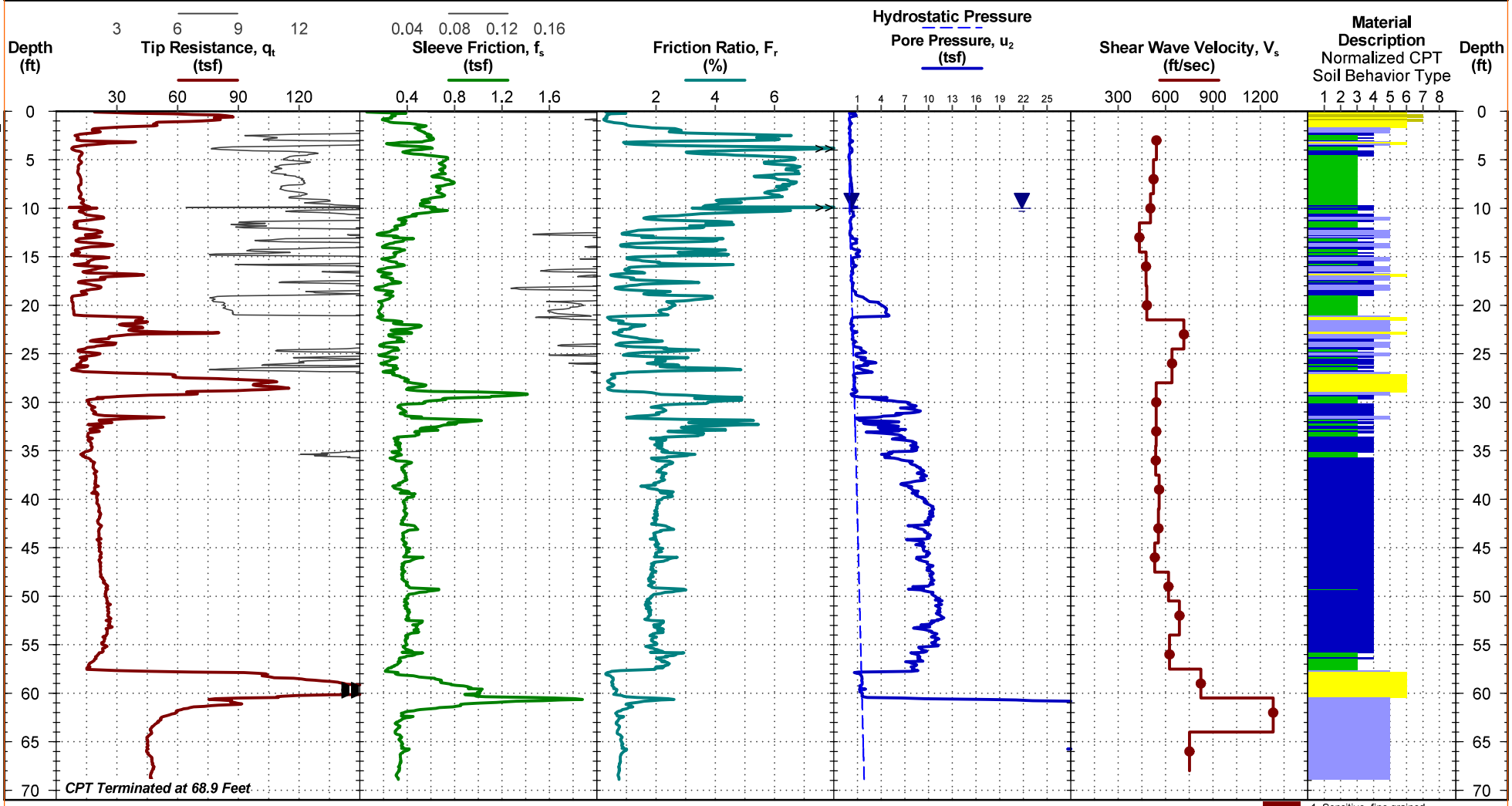
PROJECT: BCW&SA WTP Blowers

CLIENT: Hazen and Sawyer PC
Mt. Pleasant, SC

TEST LOCATION: See Exploration Plan

SITE: 2111 Red Bank Rd
Goose Creek, SC

Latitude: 32.9625°
Longitude: -79.9505°



CPT sensor calibration reports available upon request.

WATER LEVEL OBSERVATION

▼ 10 ft estimated water depth
(used in normalizations and correlations)

Probe no. 4986 with net area ratio of 0.865
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 10/3/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 Fifth St W
North Charleston, SC

CPT Started: 5/11/2018
CPT Completed: 5/11/2018
Rig: Pagani TG73-200
Operator: B. Rozier
Project No.: EN185113

BORING LOG NO. HAB AT CPT-2

PROJECT: BCW&SA WTP Blowers

CLIENT: Hazen and Sawyer PC
Mt. Pleasant, SC

SITE: 2111 Red Bank Rd
Goose Creek, SC

LOCATION See Exploration Plan

Latitude: 32.9629° Longitude: -79.9504°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE
		SILTY SAND (SC-SM), with grass and grassroots, brown			
	0.5	**SILTY SAND (SC-SM)**, dark brown			
	1.5	**SANDY LEAN CLAY (CL)**, brown to tan			
	4.0	***Boring Terminated at 4 Feet***			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: N/A

Advancement Method:
Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No Groundwater Encountered

Terracon
1450 Fifth St W
North Charleston, SC

Boring Started: 05-11-2018 | Boring Completed: 05-11-2018

Drill Rig: N/A | Driller: B. Rozier

Project No.: EN185113

BORING LOG NO. HAB AT SCPT-1

PROJECT: BCW&SA WTP Blowers

CLIENT: Hazen and Sawyer PC
Mt. Pleasant, SC

SITE: 2111 Red Bank Rd
Goose Creek, SC

LOCATION See Exploration Plan

Latitude: 32.9625° Longitude: -79.9505°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE
		SILTY SAND (SC-SM), with grass and grassroots, brown			
	0.4	**SILTY SAND (SC-SM)**, brown to tan			
	2.5	**SANDY LEAN CLAY (CL)**, brown to tan			
	4.0	***Boring Terminated at 4 Feet***			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: N/A

Advancement Method:
Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No Groundwater Encountered

Terracon
1450 Fifth St W
North Charleston, SC

Boring Started: 05-11-2018 | Boring Completed: 05-11-2018

Drill Rig: N/A | Driller: B. Rozier

Project No.: EN185113

KESSLER DYNAMIC CONE PENETROMETER LOG

Project Name	BCW&SA WTP Blower Pad
Project Number	EN185113
Date	5/16/2018
Location	2111 Red Bank Road, Goose Creek, SC
Groundwater Level	Groundwater not encountered

Tech:	J. Bandle
Ground Surface Conditions:	
pavement (core performed at DCP Location)	

DCP DATA

Penetration (in)	No of Blows
2	2
4	2
6	5
8	7
10	8
12	8
14	5
16	1
18	2
20	3
22	4
24	6
26	7
28	6
30	8
32	11
34	11
36	8
38	8
40	9
42	10
44	9
46	26
48	30

HAND AUGER DATA

Depth (in)		Soil Description
From	To	
0	12	Silty sand, SM, tan with aggregate base course
12	26	Sandy lean clay, CL, brown to gray trace aggregate base course
26	40	Sandy lean clay, CL, brown to light brown
40	48	Silty sand, SM, brown

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SUPPORTING INFORMATION

CPT GENERAL NOTES

DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

To be reported per ASTM D5778:

Uncorrected Tip Resistance, q_c
Measured force acting on the cone divided by the cone's projected area

Corrected Tip Resistance, q_t
Cone resistance corrected for porewater and net area ratio effects
$q_t = q_c + u_2(1 - a)$

Where a is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

Pore Pressure, u
Pore pressure measured during penetration
u_1 - sensor on the face of the cone
u_2 - sensor on the shoulder (more common)

Sleeve Friction, f_s
Frictional force acting on the sleeve divided by its surface area

Normalized Friction Ratio, F_r
The ratio as a percentage of f_s to q_t, accounting for overburden pressure

To be reported per ASTM D7400, if collected:

Shear Wave Velocity, V_s
Measured in a Seismic CPT and provides direct measure of soil stiffness

DESCRIPTION OF GEOTECHNICAL CORRELATIONS

Normalized Tip Resistance, Q_{tn}
$Q_{tn} = ((q_t - \sigma_{v0})/P_a)(P_a/\sigma'_{v0})^n$
$n = 0.381(I_c) + 0.05(\sigma'_{v0}/P_a) - 0.15$

Over Consolidation Ratio, OCR
$OCR\ (1) = 0.25(Q_{tn})^{1.25}$
$OCR\ (2) = 0.33(Q_{tn})$

Undrained Shear Strength, S_u
$S_u = Q_{tn} \times \sigma'_{v0}/N_{kt}$
N_{kt} is a soil-specific factor (shown on S_u plot)

Sensitivity, S_t
$S_t = (q_t - \sigma_{v0}/N_{kt}) \times (1/f_s)$

Effective Friction Angle, ϕ'
$\phi'\ (1) = \tan^{-1}(0.373[\log(q_t/\sigma'_{v0}) + 0.29])$
$\phi'\ (2) = 17.6 + 11[\log(Q_{tn})]$

Unit Weight, γ
$\gamma = (0.27[\log(F_r)]+0.36[\log(q_t/atm)]+1.236) \times \gamma_{water}$
σ_{v0} is taken as the incremental sum of the unit weights

Small Strain Shear Modulus, G_0
$G_0\ (1) = \rho V_s^2$
$G_0\ (2) = 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{v0})$

Soil Behavior Type Index, I_c
$I_c = [(3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2]^{0.5}$

SPT N_{60}
$N_{60} = (q_t/atm) / 10^{(1.1268 - 0.2817Ic)}$

Elastic Modulus, E_s (assumes $q/q_{ultimate} \sim 0.3$, i.e. FS = 3)
$E_s\ (1) = 2.6\psi G_0$ where $\psi = 0.56 - 0.33\log Q_{tn,clean\ sand}$
$E_s\ (2) = G_0$
$E_s\ (3) = 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{v0})$
$E_s\ (4) = 2.5q_t$

Constrained Modulus, M
$M = \alpha_M(q_t - \sigma_{v0})$
For $I_c > 2.2$ (fine-grained soils)
$\alpha_M = Q_{tn}$ with maximum of 14
For $I_c < 2.2$ (coarse-grained soils)
$\alpha_M = 0.0188 \times 10^{(0.55Ic + 1.68)}$

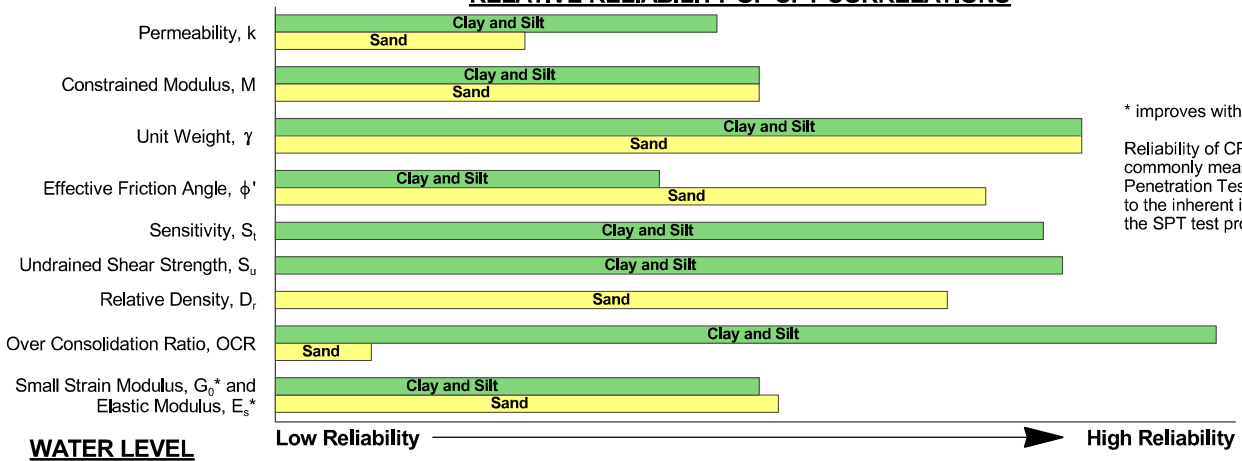
Hydraulic Conductivity, k
For $1.0 < I_c < 3.27$ $k = 10^{(0.952 - 3.04Ic)}$
For $3.27 < I_c < 4.0$ $k = 10^{(-4.52 - 1.37Ic)}$

Relative Density, D_r
$D_r = (Q_{tn} / 350)^{0.5} \times 100$

REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include q_t, f_s, and u. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. To this end, more than one correlation to a given parameter may be provided. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

RELATIVE RELIABILITY OF CPT CORRELATIONS



* improves with seismic V_s measurements

Reliability of CPT-predicted N_{60} values as commonly measured by the Standard Penetration Test (SPT) is not provided due to the inherent inaccuracy associated with the SPT test procedure.

WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated:"

Measured - Depth to water directly measured in the field

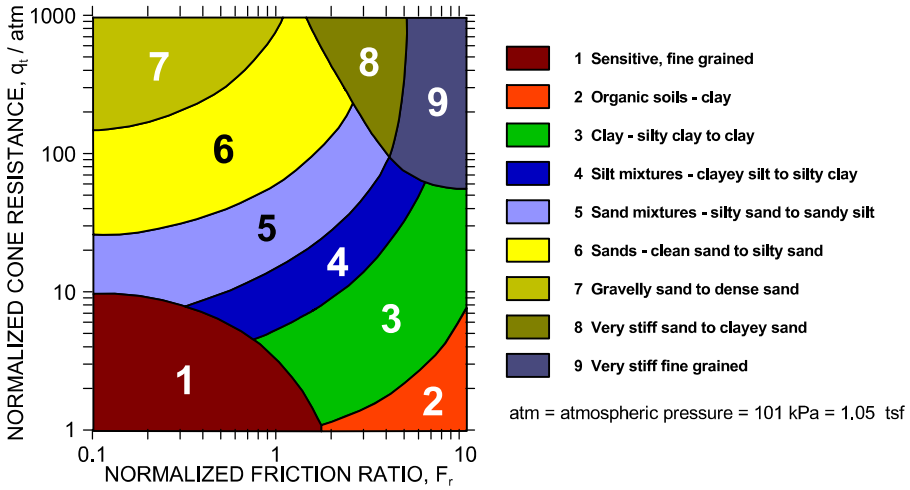
Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance (q_t), friction resistance (f_s), and porewater pressure (u_2). The normalized friction ratio (F_r) is used to classify the soil behavior type.

Typically, silts and clays have high F_r values and generate large excess penetration porewater pressures; sands have lower F_r's and do not generate excess penetration porewater pressures. The adjacent graph (Robertson *et al.*) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.



atm = atmospheric pressure = 101 kPa = 1.05 tsf

REFERENCES

Kulhawy, F.H., Mayne, P.W., (1997). "Manual on Estimating Soil Properties for Foundation Design," Electric Power Research Institute, Palo Alto, CA.

Mayne, P.W., (2013). "Geotechnical Site Exploration in the Year 2013," Georgia Institue of Technology, Atlanta, GA.

Robertson, P.K., Cabal, K.L. (2012). "Guide to Cone Penetration Testing for Geotechnical Engineering," Signal Hill, CA.

Schmertmann, J.H., (1970). "Static Cone to Compute Static Settlement over Sand," *Journal of the Soil Mechanics and Foundations Division*, 96(SM3), 1011-1043.

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UNIFIED SOIL CLASSIFICATION SYSTEM

Morningstar Storage Summerville ■ Summerville, South Carolina

■ Terracon Project No. EN175278

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.