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DENTON,H.R. Office of Nuclear Reactor Regulation, Director

SUBJECT: Forwards response to request for addl info re NUREG-0313, "Technical Rept on Matl Selection & Processing Guidelines for BWR Coolant Pressure Boundary Piping."

All Repts

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Iowa Electric Light and Power Company

December 21, 1982
NG-82-2784

LARRY D. ROOT
ASSISTANT VICE PRESIDENT
NUCLEAR GENERATION

Mr. Harold Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
NUREG-0313, Rev. 1, Request for Additional Information

Dear Mr. Denton:

This letter and attachments are submitted in response to the NRC's request for additional information dated November 8, 1982 regarding NUREG-0313, Rev. 1, IGSCC. In accordance with your request, a copy of this response is also being provided to EG&G Idaho, Inc.

Most of the information requested in your letter has been provided to the NRC in the following three principal documents (1) the DAEC FSAR and UFSAR, (2) Iowa Electric letter NG-82-2653 dated December 1, 1982 submitted in response to IE Bulletin 82-03, and (3) Iowa Electric letter LDR-81-225 dated June 30, 1981. Attachment 1 to this letter identifies the documentation applicable to your individual questions. Attachments 2 through 5 provide copies of this documentation.

Very truly yours,

Larry D. Root

Larry D. Root
Assistant Vice President
Nuclear Generation

LDR/WJM/rh*
Attachments:
(1) Response to NRC letter of 11/8/82
(2) DAEC leakage monitoring information
(3) DAEC UT procedure
(4) DAEC Response to IEB 82-03
(5) DAEC letter LDR-81-225 dated 6/30/81
(6) DAEC Core Spray SRI Numbers

cc: W. Miller
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Commitment Control No. 82-0469

A001

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ATTACHMENT 1

NG-82-2784
Dec. 21, 1982

Response to questions contained in
November 8, 1982 NRC letter

NRC Item 1

1. Unidentified Leakage Monitoring. (IV.B.1 of NUREG-0313, Rev. 1)

   a. Identify the methods to detect and monitor unidentified leakage in the pressure boundary piping of your BWR. Some of these methods are enumerated in Regulatory Guide 1.45, Paragraph b.

   b. Please fill out the attached table of information regarding the systems identified in the above paragraph.

Response to Item 1

The requested information is contained in Attachment 2 which are excerpts from the DAEC UFSAR, Technical Specifications, and procedures.

NRC Items 2a & b

2. Augmented ISI of Partially Nonconforming Service Sensitive Pipe

   Attachment 1 of the L. D. Root to Harold Denton letter of June 30, 1981 (LDR-81-225) states that "Augmented inservice inspection has been done on the above systems in accordance with the guidelines of NUREG-0313, Rev. 1."

   a. Please identify the methods for augmented ISI of the partially nonconforming service sensitive pipe (IV.B.3 of NUREG-0313 Rev. 1).

   b. Provide a copy of specifications for the augmented ISI method or methods. (IV.B.3 of NUREG-0313 Rev. 1).

Response to Items 2a & b

DAEC utilizes ultrasonic testing for volumetric examination. If interpretation of ultrasonic results warrant, radiographic technique may also be applied. Further, to meet the ASME code, certain components and supports receive surface examinations utilizing Dye Penetrant or Magnetic Particle. All systems and components also receive visual examinations prior to other techniques being employed. Attachment 3 contains a copy of our procedure UT-27 which provides the DAEC ultrasonic testing procedures.

NRC Item 2c

c. Identify each of the augmented ISI methods used and the training and certification levels the individuals using those methods received. (IV.B.3 of NUREG-0313 Rev. 1). Indicate if cracked specimens are used in your training.

Response to Item 2c

Examiners are certified in accordance with the guidelines of SNT-TC-1A. In addition, Attachment 4 contains information on the DAEC Level III inspector demonstration on Nine Mile Point samples in Columbus, Ohio.

NRC Items 2d, e, & f

d. Identify the proportion of the partially nonconforming service sensitive pipe that is being inspected. (IV.B.2.b of NUREG-0313 Rev. 1).

e. Identify the inspection interval of each system of the partially nonconforming service sensitive pipe. (IV.B.2.b of NUREG-0313 Rev. 1).

f. Identify the Stress Rule Index Numbers for the welded joints in the partially nonconforming service sensitive pipe. (IV.B.1.b (6) of NUREG-0313 Rev. 1).

Response to Items 2d, e, & f

As identified in Attachment 5, DAEC pipe and fittings that are classified as partial non-conforming and service sensitive are the following:

(A) Recirculation System Bypass

(B) Core Spray spools that connect carbon steel pipe to stainless steel safe-end extensions at the RPV nozzles

(C) CRD Hydraulic return spool that connects carbon steel pipe to the RPV nozzle

(D) Reactor water cleanup systems

NUREG-0313, Revision 1 and Attachment 5, Augmented Inservice Inspection guidelines are being applied to all of the above piping. The SRI numbers and inspection plans for the upcoming DAEC refueling outage for (A) are identified in Attachment 4. The SRI numbers for (B) are provided in Attachment 6. The (B) piping is being inspected again this outage. The (C) piping has been inspected during outages in 1975, 1977, 1978, 1980 and 1981. SRI numbers have not been calculated for this piping. The (D) piping has been inspected in 1978, 1980 and 1981 outages. SRI numbers have not been calculated for this piping.

NRC Items 3a, b & c

3. Augmented ISI of Partially Nonconforming Nonservice Sensitive Piping

Attachment 1 of the L. D. Root to Harold Denton letter of June 30, 1981 (LDR-81-225) gives some information on partially nonconforming nonservice sensitive piping (hereinafter piping).

a. Please identify the methods for augmented ISI of the piping (IV.B.3 of NUREG-0313 Rev. 1).

b. Please provide a copy of the specifications for the augmented ISI methods or methods (IV.B.3 of NUREG-0313 Rev. 1).

c. Identify each of the augmented ISI methods used and the training and certification levels the individuals using those methods received. Indicate if cracked specimens are used in your training. (IV.B.3 of NUREG-0313 Rev. 1).

Response to Items 3a & b

See Response to items 2a, b and c above.

NRC Items 3d, e & f

d. Identify the proportion of the piping that is being inspected (IV.B.2.b of NUREG-0313 Rev. 1).

e. Identify the Stress Rule Index Numbers for the welded joints in the partially piping. (IV.B.1.b (6) of NUREG-0313 Rev. 1).

f. Identify the proposed inspection interval for each system of partially piping (IV.B.1.b of NUREG-0313 Rev. 1).

Response to Items d, e & f

As identified in Attachment 5, DAEC pipe and fittings that are classified as Partially Nonconforming Nonservice Sensitive Piping are the following:

(A) Recirculation System except the bypass pipe
(B) RHR stainless steel transition spools to the recirculation system
(C) Liquid Level Control (Reactor Vessel)
(D) Instrumentation piping (Reactor Vessel)

NUREG-0313, Revision 1 and Attachment 5 Augmented Inservice Inspection guidelines are being applied to all the above piping. The SRI numbers and inspection plans for the upcoming DAEC refueling outage for (A) and (B) are identified in Attachment 4. Appropriate portions of (C) and (D) piping (including dissimilar metal "BF" welds) are scheduled for inspection during the upcoming 1983 DAEC refueling outage. SRI numbers have not been calculated for this piping.

50-331

RESPONSE TO REQUEST FOR INFO ON TECHNICAL REPT. OF MAT'L SELECTION & PROCESSING GUIDELINES FOR BWR COOLANT PRESSURE-BOUNDARY PIPING

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ATTACHMENT 2

5.2.5 DETECTION OF LEAKAGE THROUGH REACTOR COOLANT PRESSURE BOUNDARY

Reliable means are provided to detect leakage from the nuclear system barrier inside the drywell. Nuclear system leakage rate limits are established so that appropriate action can be taken before the integrity of the nuclear system process barrier is unduly compromised.

5.2.5.1 Safety Design Bases

The nuclear system leakage rate limits are set such that corrective action can be taken before one of the following occurs:

1. A threat of significant compromise to the nuclear system process barrier.

2. A leakage rate in excess of the coolant makeup capability to the reactor vessel.

3. A leakage rate in excess of the removal capability of the drywell sump pumps.

The nuclear system leakage detection system employs diverse methods to indicate leakage within the drywell.

5.2.5.2 Description

5.2.5.2.1 General

Reliable means are provided to detect leakage from the nuclear system barrier inside the drywell. Nuclear system leakage rate limits are established so that appropriate action can be taken before the integrity of the nuclear system process barrier is unduly compromised.

The DAEC design includes a nuclear system leak detection, isolation, processing, and makeup system. This system (made up of many normal station operational subsystems) provides for leakage control capability. This capability includes the following:

1. Identifying the reactor building (or reactor primary system) leakage sources.

2. Efficiently isolating and controlling the sources.

3. Effectively removing the residual leakage water (before and after isolation).

4. Conveniently replacing the leakage liquid and/or restoring the source system function.

These functions are accomplished under normal operation or postaccident conditions in a manner in which normal (10 CFR 20) or accident (10 CFR 100) offsite dose limits do not exceed established values and in a manner in which the core and the containment cooling continuity is not impaired or negated.

The leakage considered here is limited to that water or steam released from the nuclear system process barrier inside the primary containment. Leakage inside the drywell is treated separately from leakage elsewhere in the plant because the drywell contains a high concentration of nuclear system piping and is totally inaccessible during reactor operation.

If a leak occurs, the drywell will contain the released matter that will be present in the liquid, gaseous, and vapor phases. This will result in the collection of water in the sumps, a possible increase in drywell temperature, pressure, and relative humidity, an increase in the air-conditioning heat load, and an increase in the radioactivity of the drywell atmosphere. The closed limited volume of the drywell enhances the detection sensitivity.

5.2.5.2.2 Leakage Sources

Total leakage within the drywell is divided into two classifications--identified and unidentified--depending on whether the drywell equipment drain sump (identified) or the drywell floor drain sump (unidentified) receives the fluid:

Identifiable Leakage (Equipment Drain Sump)

Identifiable leakage into the equipment drain sump is composed of normal seal and valve packing leakage and does not represent a safety consideration so long as the leakage is small compared to the available reactor coolant makeup capacity.

Most valves and pumps in the nuclear system inside the drywell are equipped with double seals; leakage through the primary seal is piped to the equipment drain sump.

Leakage from the reactor vessel head flange gasket is piped to a collection chamber and then to the equipment drain sump. The chamber filling time is periodically timed during plant operation, and the flange gasket leakage rate is calculated. (Section 7.6.4 presents a more detailed discussion.)

Leakage from the main steam relief and safety valves is identified by downstream temperature sensors that read out in the main control room. Relief valve discharge is directed to the suppression pool.

Unidentifiable Leakage (Floor Drain)

The unidentifiable leakage is composed of all leakage from the reactor primary system that is not defined as identifiable leakage. This unidentified leakage is collected in the drywell floor drain sump. Vapor that is condensed by the drywell ventilation system will drain to this sump.

The sump systems and input sources are indicated on Figure 11.2-2.

5.2.5.2.3 Leak Detection Methods

The following seven methods are used to detect leakage in the primary containment:

1. Equipment drain sump flow.
2. Floor drain sump flow.
3. Drywell ventilation system cooling water temperature.
4. Drywell pressure.
5. Drywell temperature.
6. Drywell atmosphere radioactivity.

Instrumentation is provided for the primary containment sumps having a capability to detect steam leakage of 0.5 gpm within a 45-min period. The response time depends on the amount of background leakage but will not exceed the interval between pumping cycles. The higher the leak rate the shorter the response time. Alarms are provided to annunciate leakage. The alarm setpoints will be adjustable from 0 to 5 gpm for the floor drain sump (unidentified leakage) and 0 to 25 gpm for the equipment drain sump (identified leakage), thus giving the capability of having alarm annunciation set at or below the license limit and providing immediate response when the preselected rate is reached or exceeded.

The unidentified leakage rate is the portion of the total leakage rate received in the drywell sumps that is not identified. A threat of significant compromise to the nuclear system process barrier exists if the barrier contains a crack that is large enough to propagate rapidly (i.e., critical crack). An allowance for leakage that does not compromise barrier integrity and is not identifiable is made for normal plant operation. The unidentified leakage rate limit for the DAEC is established at the 5-gpm rate to allow time for corrective action before the process barrier could be significantly compromised. This 5-gpm unidentified leakage rate is substantially lower than the calculated flow from a subcritical crack in a primary system pipe. The experimental as well as mathematical background is summarized below.

<u>Critical Crack Length</u>

Both the GE[4] and the BMI[5] test results indicate that formulas for theoretical fracture mechanics do not predict critical crack length, but that satisfactory empirical expressions may be developed to fit test results. A simple equation (for axially oriented through-wall cracks) that fits the data in the range of normal design stresses (for carbon steel pipe) is

$$\ell_c = \frac{15{,}000\ D}{\sigma_h}$$ (see data correlation on Figure 5.2-14).

ℓ_c = critical crack length, in.

D = mean pipe diameter, in.

σ_h = nominal hoop stress, psi

Crack Opening Displacement

The theory of elasticity predicts a crack-opening displacement of

$$w = \frac{2\ell\sigma}{E}$$

where

ℓ = crack length
σ = applied nominal stress
E = Young's modulus

Measurements of crack-opening displacement made by BMI show that local yielding and bending greatly increases the crack opening displacement as the applied stress σ approaches the failure stress σ_f. A suitable correction factor for plasticity effects is

$$C = \sec\left[\frac{\pi}{2}\frac{\sigma}{\sigma_f}\right]$$

The crack opening area is given by

$$A = C\pi\omega\ell/4$$

or

$$A = \frac{\pi\ell^2\sigma}{2E}\sec\left[\frac{\pi}{2}\frac{\sigma}{\sigma_f}\right]$$

For a given crack length ℓ, σ_f = 15,000 D/ℓ.

Leakage Flow Rate

The maximum flow rate for the blowdown of saturated water at 1000 psi is 55 lb/sec-in.^{2}, and for saturated steam the rate is 14.6 lb/sec-in.^{2} (Reference 6). Friction in the flow passage reduces this rate, but for cracks leaking at 5 gpm (0.7 lb/sec) the effect of friction is small. The required leak size for 5-gpm flow is

A = 0.0126 in.^{2} (saturated water)
A = 0.0475 in.^{2} (saturated steam)

Figure 5.2-15 shows general relationships between crack length, leak rate, stress, and line size using the mathematical model described above. The asterisks in the figure denote conditions at which the crack-opening displacement is 0.1 in., at which time instability is imminent. This provides a realistic estimate of the leak rate to be expected from a crack of critical size. In every case, the leak rate from a crack of critical size is significantly greater than the 5-gpm criteria.

From the mathematical model described above, the critical crack length and the 5-gpm crack length have been calculated for representative BWR pipe sizes and pressure (1050 psi). Results are tabulated as follows.

The lengths of through-wall cracks that would leak at the rate of 5 g/min given as a function of wall thickness and nominal pipe size are

Nominal Pipe Size	Wall Thickness (in.)	Crack Length ℓ (in.) Steam Line	Crack Length ℓ (in.) Water Line
4 in., Schedule 80	0.337	7.15	4.91
12 in., Schedule 80	0.687	8.46	4.76
20 in., main steam	0.758	7.39	--
22 in., recirculation	0.975	--	4.39

The ratios of crack length ℓ to the critical crack length ℓc as a function of nominal pipe size are

Nominal Pipe Size	Ratio $\ell/\ell c$ Steam Line	Ratio $\ell/\ell c$ Water Line
4 in., Schedule 80	0.745	0.510
12 in., Schedule 80	0.432	0.243
20 in., main steam	0.342	--
22 in., recirculation	--	0.158

It is important to recognize that the failure of ductile piping with a long, through-wall crack is characterized by large crack-opening displacements that precede unstable rupture. Judging from observed crack behavior in the GE and BMI experimental programs involving both circumferential and axial cracks, it is estimated that leak rates of hundreds of gpm will precede crack instability. Measured crack-opening displacements for the BMI experiments were in the range of 0.1 to 0.2 in. at the time of incipient rupture, corresponding to leaks of the order of 1 in.^{2} in size for plain carbon steel piping. For austenitic stainless steel piping, even larger leaks are expected to precede crack instability, although there is insufficient data to permit quantitative prediction.

The results given are for a longitudinally oriented flaw at normal operating hoop stress. A circumferentially oriented flaw could be subjected to stress as high as the 550°F yield stress, assuming that high thermal expansion stresses exist. A good mathematical model that is well supported by test data is not available for the circumferential crack. Therefore, it is assumed that the longitudinal crack, subject to a stress as high as 30,000 psi, constitutes a "worst case" with regard to leak rate versus critical size relationships. Given the same stress level, differences between the circumferential and longitudinal orientations are not expected to be significant in this comparison.

5.2.5.2.3.1 Equipment Drain and Floor Drain Sumps. The equipment drain sump system is actually composed of two sumps: the equipment drain sump is located beneath the reactor inside the reactor vessel pedestal and is directly joined to the equipment drain pump sump located inside the drywell but outside the pedestal. These two sumps will be generally referred to as the equipment drain sump.

The equipment drain sump level is used to control the drain pumps and provide alarms to control room personnel.

The pump control and alarm function is as follows.

At the lowest of the high water level settings, the preferred pump is automatically started. If the water level continues to rise, a higher water level setting starts the standby pump and actuates an alarm in the control room. When the water level decreases to a low water level setting, the pumps are stopped and the automatic pump selector switch reverses the roles of the preferred and standby pumps.

As the water that has collected in the sump is pumped out, the discharge flow is monitored. The flow rate is continually plotted on a recorder in the control room. The total volume pumped is indicated in the control room. The sump pump discharge flow duration, the frequency of pump operation, and the volume pumped can be used to provide a measure of the leakage rate.

Excessive leak rates are indicated by a control room alarm. This alarm is actuated by either of two timed conditions: the pump starting at shorter intervals than would be required if the alarm setpoint leak rate existed, or the pump running longer than would be required to lower the level to the shutoff point.

The drywell floor drain sump system is monitored and controlled in the same manner as the drywell equipment drain sump.

5.2.5.2.3.2 Drywell Ventilation. The drywell ventilation system is a water-cooled, forced-air system, using well water as the cooling medium. In this system, the temperature of the gas entering and leaving the cooler and the outlet temperature of the well water are monitored. Once steady-state operation is established, variations of these parameters can indicate possible leaks. Since the inlet water has an essentially constant temperature, a rise in outlet temperature indicates additional heat load on the cooling coils and could be indicative of a leak. Either high air or water outlet temperature will actuate an alarm.

5.2.5.2.3.3 Drywell Pressure and Temperature. The drywell temperature and pressure are monitored, indicated, and recorded in the control room. The sample points and instrumentation are indicated in Figure 6.2-44.

The drywell atmosphere radioactivity detector provides a sensitive and rapid indication of increased nuclear system leakage. The drywell environment is continuously sampled from three locations that are chosen to provide both a representative gas mixture and an indication of the location of the leakage. The lines used for the oxygen sampling system are also used for the drywell atmosphere radioactivity detector in order to take advantage of existing piping, penetrations, and isolation capabilities. The piping runs to the detector are as short and as straight as possible to minimize the particulate deposition and are constructed of stainless steel to minimize chemical reactions.

The drywell atmosphere radioactivity detector is designed so that steam leakage rates as low as 1 gpm can be detected.

The sampled air undergoes three separate processes in which the radioactive noble gas, halogen, and particulate content is determined. This system is thus a three-channel monitoring system. The processed air is returned to the drywell.

The readings for each channel are fed into a pen recorder so that a permanent record of the drywell atmosphere radioactivity is maintained. The system will alarm locally and in the control room to indicate system failure or alarm conditions. No automatic action is initiated by the system. Provisions have been made for "grab" sample bottles that can be quickly removed from the sample lines without disturbing the flow and analyzed for definitive isotopic content. For a discussion of primary system leak detection outside of primary containment, refer to Section 3.11.

5.2.5.3 Safety Evaluation

5.2.5.3.1 General

The different drywell parameters that are discussed in Section 5.2.5 provide diverse methods for determining if an increased leak rate exists within the drywell. The allowable leakage rates have been based on the predicted and experimentally determined behavior of cracks in pipes, the ability to make up coolant system leakage, the normally expected background leakage due to equipment design, and the detection capability of the various drywell monitors.

Based on the behavior of cracks, a 5-gpm leak rate limit has been assigned to unidentified leaks and a 25-gpm leak rate limit for identified leaks. Experience has shown that normal leak rate is 4 gpm into the equipment drain sump and 0 to 0.5 gpm into the floor drain sump.

The sump working capacities and pump discharge capacities are large enough to accept the design leak rates. The sump working capacity is the amount of water between the low-level pump trip and the high-high-level alarm point. The equipment drain sump (approximate working capacity, 450 gal) and the floor drain sump (approximate working capacity, 225 gal) are drained by two 50-gpm pumps. This pump capacity permits one pump in each sump to remove the design total leakage because of the possibility that most of the leakage could flow into one sump.

5.2.5.3.2 Behavior of Cracks

The behavior of cracks in piping systems has been experimentally and analytically investigated as part of an NRC-sponsored Reactor Primary Coolant System Rupture Study (the Pipe Rupture Study). Analysis using the data obtained in this study has shown that there is a high probability that a leaking crack can be detected before it grows to a dangerous or critical size because of mechanically or thermally induced cyclic loading, or stress corrosion cracking, or some other mechanism characterized by gradual crack growth. Earthquake and normal vibration stresses are considered in the determination of the critical crack size. For the crack size that gives a water leakage of 15 gpm, the probability of rapid propagation was calculated to be 10^{-4}. The crack area corresponding to a 15-gpm leak is approximately 1.8×10^{-4} ft^2.

The Technical Specification unidentified leakage rate has been set at 5 gpm to provide further conservatism.

5.2.5.3.3 Total Leakage Rate Limit

The criterion for establishing the total leakage rate limit is based on the makeup capability of the CRD and RCIC systems and is independent of the feedwater system, normal ac power, and the core standby cooling systems. The CRD system supplies 42 gpm into the reactor vessel; the RCIC system can supply 425 gpm through the feedwater sparger to the reactor vessel. The total leakage rate limit is set at less than 0.1 of this value or 30 gpm.

5.2.5.3.4 Drywell Leak Detection

The sump-fill timer and pump-out timer for both the equipment drain sump and floor drain sump are set to alarm at levels that provide adequate separation from expected leak rates to avoid spurious alarms but low enough to indicate significant leaks. Exact leak rates can be determined from the flow indications in the control room, and any increase beyond the normal leak rate will be apparent to control room personnel.

The drywell ventilation system consists of several coolers, each with a separate heat load. The calculated well water differential temperature is 30° to 45°F depending on the cooler in question. It is therefore reasonable to assume that a 5°F rise in outlet temperature is detectable.

If one assumes the following, one can determine that, for a given size break, steam and water are equally detectable although four times as much reactor water is lost through a water break.

1. A 5°F rise in cooler outlet water temperature is detectable by control room personnel.

2. Normal cooler heat load is 740,000 Btu/hr.

3. A 1000-psig blowdown of saturated steam or water.[7]

4. Fifty percent of the water and 100% of the steam become airborne.

The alarms associated with the cooler air and water outlet provide additional indication should a sudden increase in leak rate occur.

Drywell temperature and, to some extent, drywell pressure are controlled by the drywell ventilation system. As the heat load on the cooling coil is increased, the average drywell temperature will increase. If this temperature exceeds the setpoint, an alarm will occur. The combination of increased temperature and increased absolute humidity causes the drywell pressure to increase. A small increase in pressure above the setpoint will actuate an alarm; a 2-psig increase indicates a larger leak and is used to initiate a scram and nuclear steam supply isolation. Low reactor water level will also indicate larger leaks and initiate a scram and isolation.

If the drywell ventilation system is assumed to be saturated so that the steam or water from a leak does not condense, there will be an increase in drywell temperature, pressure, and relative humidity with respect to time, providing an indication of the sensitivity of these parameters.

The drywell atmosphere radioactivity detector serves as a sensitive, reliable backup to the other methods of leak detection. It is anticipated that the particulate detector will be the primary indication of leakage, with the halogen and noble gas detectors serving as indications of the drywell environment if drywell venting is required. These detectors, in conjunction with an isotopic analysis, can be used to indicate whether the detected leak is from a steam or water system.

The detector units are shielded to minimize the effect of background activity and thereby increase the detection sensitivity. The individual units have the capability of being tested for reaction to a source and calibrated. Since the background contamination and deposition--chemical reaction effects--cannot be predetermined, and since it is an increase in detected values that indicates a leak, the alarm points will be determined by operator experience; the setpoints will be low enough to provide the quickest indication without receiving spurious alarms.

It is expected that this system will provide at least an order of magnitude reduction in the leak size that can be detected and will also reduce the time delay in sensing the condition.

5.2.5.4 Inspection and Testing

The nuclear system leak detection system is an operational system in daily use and as such does not require periodic testing to ensure operability.

The following list shows where reactor vessel pressure measuring instruments used for the automatic control of equipment or systems are discussed:

Pressure Instrumentation	Section Where Discussed
Pressure switches used to initiate a scram	Reactor Protection System (7.2)
Pressure switches used to bypass main steam line isolation valve closure scram	Reactor Protection System (7.2)
Pressure switches used for HPCI, core spray, and LPCI	Emergency Core Cooling System Control and Instrumentation (7.3.2)
Pressure transmitters and recorders used for feedwater control	Feedwater Control System (7.7.1)
Differential-pressure switches measuring differential pressure between reactor vessel and jet pump riser pipes	Emergency Core Cooling System Control and Instrumentation (7.3.2)
Differential-pressure switches measuring differential pressure between the inside of core spray sparger pipes and core inlet above the core support assembly.	Emergency Core Cooling System Control and Instrumentation (7.3.2)

7.6.4.9 Reactor Vessel Top Head Flange Leak Detection

A connection is provided on the reactor vessel flange into the annulus between the two metallic seal rings used to seal the reactor vessel and top head flanges. This connection permits the detection of leakage from the inside of the reactor vessel past the inner seal ring. The connection is piped to a collection chamber installed between two ac solenoid-operated valves. The arrangement is shown in Figure 5.1-1, Sheet 1. The upstream valve is normally open, the downstream valve normally closed. A level switch is provided to detect the accumulation of water in the collection chamber. This level switch actuates an alarm in the main control room. A pressure switch is also provided to actuate the alarm in the main control room as pressure in the leakage collection piping becomes abnormally high. A pressure indicator is provided to indicate the pressure inside the piping arrangement. The level switch is located inside the primary containment, and the pressure instruments are located outside the drywell but inside the reactor building. The specifications for the level and pressure instruments are given in Table 7.6-8. The two solenoid valves are controlled by a switch in the main control room. The positions of the valves are indicated by lights. If leakage past the inner seal ring is indicated, the upstream valve can be closed and the downstream valve can be opened by remote manual operation from the main control room. This action routes the accumulated leakage to the drywell equipment drain sump. After the collection chamber is drained, the solenoid-operated valves can be returned to their normal positions. The leakage rate can be determined by timing the period until the level alarm is reactivated (Section 5.2.5).

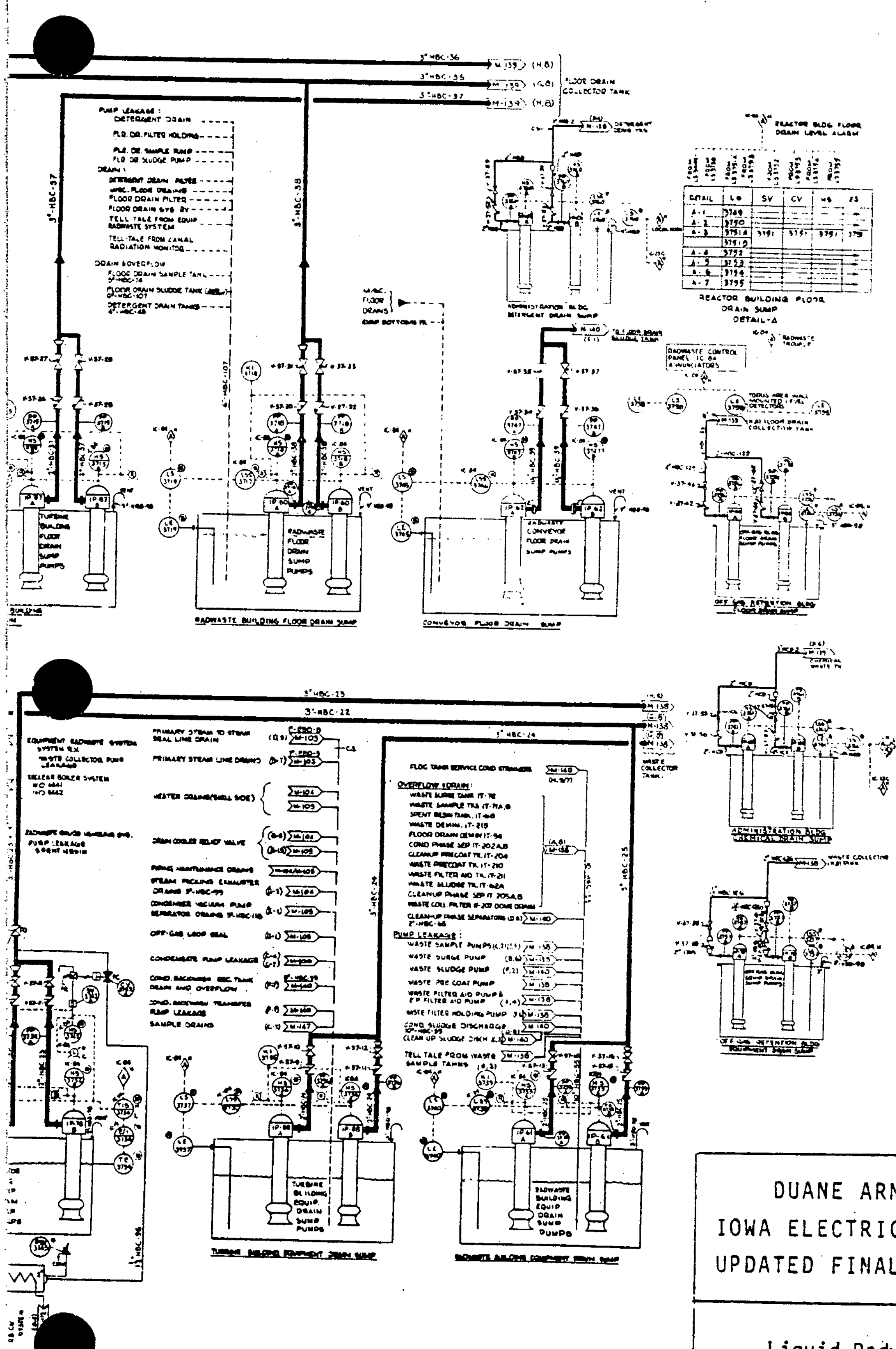
7.6.4.10 Safety Evaluation

The reactor vessel instrumentation is designed to provide sufficient continuous indication of key reactor vessel operating parameters during planned operations such that the operator can efficiently monitor these parameters and anticipate any approach to operating conditions that could lead to any unacceptable safety results.

The redundancy of all indicators provided ensures that the possibility that all instrumentation could be lost simultaneously is so remote as to be negligible. In addition, sensors providing safety signals to the RPS and engineered safeguards systems for scram and isolation functions are separate from these indicator sensors so that a loss of indication does not directly obviate protection against accidents and transients.

7.6.4.11 Inspection and Testing

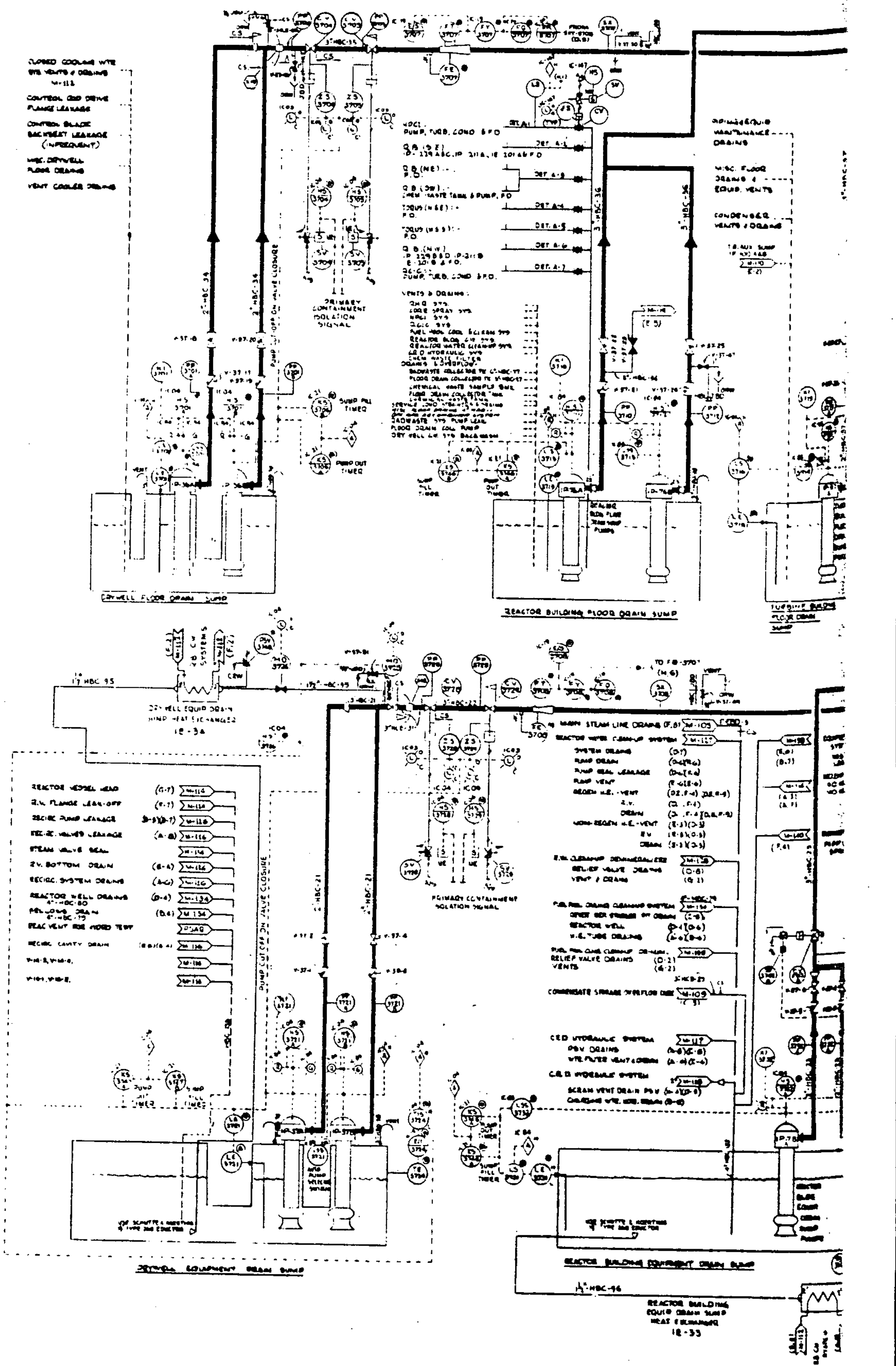
Pressure, differential pressure, water level, and flow instruments are located in the reactor building and are piped so that calibration and test signals can be applied during reactor operation.



DUANE ARNOLD ENERGY CENTER
IOWA ELECTRIC LIGHT & POWER COMPANY
UPDATED FINAL SAFETY ANALYSIS REPOR

Liquid Radwaste Sump System - P&ID

Figure 11.2-2


DRYWELL FLOOR DRAIN SUMP
REACTOR BUILDING FLOOR DRAIN SUMP
PRIMARY CONTAINMENT ISOLATION SIGNAL
DRYWELL EQUIPMENT DRAIN SUMP
REACTOR BUILDING EQUIPMENT DRAIN SUMP
REACTOR BUILDING EQUIP DRAIN SUMP HEAT EXCHANGER
1E-33

APPENDIX A

TO

OPERATING LICENSE DPR-49

TECHNICAL SPECIFICATIONS AND BASES

FOR

DUANE ARNOLD ENERGY CENTER

IOWA ELECTRIC LIGHT AND POWER COMPANY

CENTRAL IOWA POWER COOPERATIVE

CORN BELT POWER COOPERATIVE

DOCKET NO. 50-331

FEBRUARY 1974

LIMITING CONDITIONS FOR OPERATION	SURVEILLANCE REQUIREMENTS
C. Coolant Leakage	C. Coolant Leakage
1. Any time irradiated fuel is in the reactor vessel and reactor coolant temperature is above 212°F, reactor coolant leakage into the primary containment from unidentified sources shall not exceed 5 gpm. In addition, the total reactor coolant system leakage into the primary containment shall not exceed 25 gpm.	1. Reactor coolant system leakage shall be checked by the sump and air sampling system and recorded at least once per day.
2. Both the sump and air sampling systems shall be operable during reactor power operation. From and after the date that one of these systems is made or found to be inoperable for any reason, reactor power operation is permissible only during the succeeding seven days unless system is made operable sooner.	
3. If the conditions in 1 or 2 cannot be met, an orderly shutdown shall be initiated and the reactor shall be in a Cold Shutdown Condition within 24 hours.	
D. Safety and Relief Valves	D. Safety and Relief Valves
1. During reactor power operating conditions and prior to reactor startup from a Cold Condition, or whenever reactor coolant pressure is greater than atmospheric and temperature greater than 212°F, both safety valves and the safety modes of all relief valves shall be operable, except as specified in 3.6.D.2.	1. At least one safety valve and 3 relief valves shall be checked or replaced with bench checked valves once per operating cycle. All valves will be tested every two cycles. The setpoint of the safety valves shall be as specified in Specification 2.2.

DUANE ARNOLD ENERGY CENTER

UNIT NO. 1

IOWA ELECTRIC LIGHT AND POWER COMPANY

Reference Only

REV. 55 APPROVAL

SURVEILLANCE TEST PROCEDURE NO. 42A001

DAILY AND SHIFT INSTRUMENT CHECKS

Prepared by: ________ Ann Howard — Date: 9-20-82

Approved by: ________ FOR Operations Supervisor — Date: 9-24-82

Approved by: ________ Plant Performance Supervisor — Date: 10-5-82

Approved by: ________ Quality Control Supervisor — Date: 10-3-82

Reviewed by: ________ ALARA Coordinator — Date: 9-28-82

Reviewed by: ________ Chairman, Operations Committee — Date: 10-7-82

Approved by: ________ Plant Superintendent - Nuclear — Date: 10-8-82

Implementation Date 10 - 11 - 82

Rev. 55
9/17/82

Procedure	Tech. Spec. Section	Function	Instrument Number	Panel Number	Acceptance Criteria	Date		
4.2.d	4.9C	Spent Fuel Pool Level	NA	NA	$\geq$ 36 feet with spent fuel in Pool	______ft.	Operators Initials	
4.2.e	None	SBLC Heat Tracing Temperature Controller	NA	Local	Green light on			
4.2.f	None	Excess Flow Check Valve Status	NA	1C29	All open (red) lights ON			
4.2.g	None	All Recorders Checked for Inking	NA	NA	Inking properly Time & Date entered on Charts			
4.2.h	4.2E 4.6C	Reactor Coolant Leakage Calculation Sheet Complete	NA	NA	See Calculation Sheet (Appendix B)			
4.2.i	4.6E 4.6F	Jet Pump Flow Mismatch Calculation Sheet Complete	NA	NA	See Calculation Sheet (Appendix C)			
4.2.j	4.6E	Jet Pump Operability Calculation Sheet Complete	NA	NA	See Calculation Sheet (Appendix D)			

APPENDIX B

Reactor Coolant Leakage

All readings are to be taken at Panel 1C19.

1. Unidentified average leak rate calculation

   a. FQ 3707 present reading ____________ time of reading ____________
   b. FQ 3707 previous reading ____________ time of reading ____________
   c. Total gallons pumped (a-b) ____________
   d. Time interval (a-b) ____________ hours X 60 = ____________ min.
   e. Unidentified average leak rate = $\frac{\text{Total Gallons Pumped}}{\text{Time Interval (minutes)}}$ = ____________ gpm
   f. Maximum allowed: 5 gpm

2. Total average leak rate calculation

   a. FQ 3708 present reading ____________ time of reading ____________
   b. FQ 3708 previous reading ____________ time of reading ____________
   c. Total gallons pumped (a-b) ____________
   d. Time interval (a-b) ____________ hours X 60 = ____________ min.
   e. Identified average leak rate = $\frac{\text{Total Gallons Pumped}}{\text{Time Interval (minutes)}}$ = ____________ gpm
   f. Total average leak rate = 1.e + 2.e ____________.
   g. Maximum allowed 25 gpm.

____

Operators Initials ____________________

NOTE: An IE agreement with the NRC requires that a reactor shut-down be initiated if unidentified leakage is observed to increase by 2 gpm in a 24 hr. period, or to double in a 4 hr. period.

APPENDIX B1

Unidentified Reactor Coolant Leakage

(Complete Once per Shift)

All readings are to be taken at Panel 1C19.

1. Unidentified average leak rate calculation

a. FQ 3707 present reading ________ Time of Reading ______
b. FQ 3707 previous reading ________ Time of Reading ______
c. Total gallons pumped (a-b) _____
d. Time interval (a-b) _____ hours X 60 = _____ min.
e. Unidentified average leak rate = Total Gallons Pumped / Time Interval (minutes) = ______ gpm
f. Maximum allowed: 5 gpm
g. Drywell Floor Drain Sump fill timer set to 1 gpm above the above base line.

Operator's Initials ____________

2. Unidentified average leak rate calculation

a. FQ 3707 present reading ________ Tine of Reading ______
b. FQ 3707 previous reading ________ Time of Reading ______
c. Total gallons pumped (a-b) _____
d. Time interval (a-b) _____ hours X 60 = _____ min.
e. Unidentified average leak rate = Total Gallons Pumped / Time Interval (minutes) = ______ gpm
f. Maximum allowed: 5 gpm
g. Drywell Floor Drain Sump fill timer set to 1 gpm above the above base line.

Operator's Initials ____________

3. Unidentified average leak rate calculation

a. FQ 3707 present reading ________ Time of Reading ______
b. FQ 3707 previous reading ________ Time of Reading ______
c. Total gallons pumped (a-b) _____
d. Time interval (a-b) _____ hours X 60 = _____ min.
e. Unidentified average leak rate = Total Gallons Pumped / Time Interval (minutes) = ______ gpm
f. Maximum allowed: 5gpm
g. Drywell Floor Drain Sump fill timer set to 1 gpm above the above base line.

Operator's Initials ____________

NOTE: An IE agreement with the NRC requires that a reactor shut-down be initiated if unidentified leakage is observed to increase by 2 gpm in a 24 hour period, or doubles in a 4 hour period.

ATTACHMENT 3

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408-297-8766

SHEET 2

WNP-2 PROCEDURE COVER SHEET AND QUALIFICATION RECORD

Procedure No. UT-27 Revision No. 0

Procedure Title ULTRASONIC EXAMINATION OF NUCLEAR COOLANT SYSTEM PIPING FOR THE DUANE ARNOLD ENERGY CENTER

LMT, Inc. QA Review and Approval [signature] Level III 7-12-79
(Quality Assurance Officer)

Client Approval K.U. Harrington 3-10-81
R.A. McCrum 3-11-81

Authorized Nuclear Inspector Approval __________

Specific Qualification Record

Component	Examiners	Date
20" MS. SCH 80	KELLERHALL PECHACEK	7/8/82 [signature]

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LMT, Inc. QA Review and Approval [signature] Level III 7-12-79
(Quality Assurance Officer)

Client Approval K.U. Harrington 3-10-81
R.A. McCrann 3-11-81

Authorized Nuclear Inspector Approval ____________

Specific Qualification Record

Component	Examiners	Date
12", 18", 8" Piping	Wayne Davis, R. Hubyard, Burlingame, Brodie	3/10/81 [signature]
4" S/S Bypass Sch 80	Dave Hall, R. Burlingame, R. Hubyard	3/25/81 [signature]
8" CS Sch 80	D. HARVEY / ABRIGO	4-9-81 E.J. Thomas
20" Piping	DAVIS	4-2-81 E.J. Thomas
10" Piping	DAVIS	4-6-81 E.J. Thomas
10" Recirc	Stoey-Walker Davis	4-18-81 E.J. Thomas

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FIELD CHANGE RECORD

Procedure No. UT-27 Field Change No. 1

Procedure Title Ultrasonic Examination of Nuclear Coolant System Piping for the Duane Arnold Energy Center

Revision No. 0 Date 6-25-79

LMT, Inc. Approval E J Thomas Date 4-15-81

Client Approval K.V. Harrington Date 4-17-81

Authorized Nuclear Inspector Approval RA Gosser Date 4-23-81

Procedure Change:

Page 1, Qualification; Add Technical Manager, under T. G. Lamberts signature.

Page 2, Paragraph IV.A.; Delete words "The Cover Sheet", and add "Page 1 of This Procedure".

Page 3, Paragraph IV.B. change to read "The LMT Field Supervisor Shall Be Responsible for the Qualification of a Particular Examination".

Page 3, Paragraph VI.A.; Add sentence to read "Examiners Must be Certified a Minimum Level II in Ultrasonic Testing to Evaluate Test Results.

Page 6, Paragraph VII.E.; Add Item 3. LMT-Gel, Ultra-Gel, or Any Similiar Lightweight Couplant is Acceptable.

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FIELD CHANGE RECORD

Procedure No. UT-27 Field Change No. 1

Procedure Title Ultrasonic Examination of Nuclear Coolant System Piping for the Duane Arnold Energy Center

Revision No. 0 Date 6-25-79

LMT, Inc. Approval E. L. Thomas Date 4-15-81

Client Approval K.U. Harrington Date 4-17-81

Authorized Nuclear Inspector Approval R Gosser Date 4-23-81

Procedure Change:

Page 9, Paragraph X.A.; Change second sentence to read "Any Change in the Ultrasonic Instrument, Wedges, Transducer Cable or Transducer Requires Test Recalibration. Change third sentence to read " A Change in Qualified Personnel, Couplant, Recording Instrumentation, or Recorder Connection Cable Requires a Calibration Check, However, Instrument Alignment Verification Need Not Be Made With the Transducer Used for Testing".

Page 12, Paragraph X.C.2.; Change first sentence to read "Calibration is Performed on a Complete System on an Appropriate Basic Calibration Block at the Beginning of Each Work Shifts Testing of That Material".

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FIELD CHANGE RECORD

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Revision No. 0 Date 6-25-79

LMT, Inc. Approval E. J. Thomas Date 4-15-81

Client Approval K. U. Harrington Date 4-17-81

Authorized Nuclear Inspector Approval R Gosse Date 4-23-81

Procedure Change:

Page 17, Paragraph XI.D.4.; Change to read "Overlap Between Parallel Scans Shall Be Nominally 15%, and In No Case Less Than 10% of the Transducer Piezo-Electric Element.

Page 18, Paragraph XII.A.; Add Item 3. "The Site Level III Shall Review and Evaluate All Non Geometric Reflections in Accordance With IWA 3100 (b) of ASME XI (1974)".

Page 20, Paragraph XIV.1.; Change to read "Examination Reports Will Be Reviewed By the Assigned LMT Level III Examiner for Conformity to the Requirements of This Procedure". Add Item 2. "All Inspection Reports Shall Be Subject to Review by the Owner and Authorized Inspector".

Change page numbering from Page 18 thru F, (Final) to run consecutively.

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WNP-2 PROCEDURE COVER SHEET AND QUALIFICATION RECORD

Procedure No. UT-27 Revision No. 0

Procedure Title ULTRASONIC EXAMINATION OF NUCLEAR COOLANT SYSTEM PIPING FOR THE DUANE ARNOLD ENERGY CENTER

LMT, Inc. QA Review and Approval [signature] Level III 7-12-79
(Quality Assurance Officer)

Client Approval K.U. Harrington 3-10-81
R.A. McCracken 3-11-81

Authorized Nuclear Inspector Approval ______

Specific Qualification Record

Component	Examiners	Date

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408-297-8766

TITLE: ULTRASONIC EXAMINATION OF NUCLEAR COOLANT SYSTEM PIPING FOR THE DUANE ARNOLD ENERGY CENTER

I. PURPOSE AND SCOPE

A. Purpose

This procedure provides instructions for implementation of the requirements of the ASME Boiler and Pressure Vessel Code, Section XI, for the straight beam and angle beam contact ultrasonic examination of full penetration butt welds and adjacent base metal in wrought and cast piping made from ferritic steel in ASME Class 1 and Class 2 systems. The procedure may also be applied to austenitic steels and dissimilar metal welds where successful qualification is acheived.

B. Scope

This procedure is limited to piping systems having nominal wall thicknesses of 0.20" to 6". The examinations may be performed from either inside or outside surfaces.

QUALIFICATION:

Approved for use [signature] 7/24/79

[signature] Level III 9-12-79

II. REFERENCE DOCUMENTS

A. Applicable Code Editions

This procedure meets the requirements of the 1974 edition of ASME XI, Summer 1975 addenda.

B. Supplemental References

1. SNT-TC-1A (June 1975), "Recommended Practice for the Establishment of Personnel Qualification and Certification Programs."

2. LMT Procedure QA-6, "Qualification and Certification of NDE Personnel."

3. LMT Operating and Quality Assurance Manual.

III. DEFINITIONS

None

IV. RESPONSIBILITY

A. The Technical Manager, LMT, Inc., is responsible for the generation and control of this procedure and shall so indicate by a dated signature on the cover sheet.

IV. B. The responsible LMT Field Supervisor shall qualify the procedure for a particular examination.

V. PROCEDURE QUALIFICATION

The procedure may be qualified for specific examinations, personnel, and equipment by successful calibration.

VI. PERSONNEL REQUIREMENTS

A. Examiners using this procedure shall have levels of qualifications as per the Procedure Qualification.

B. Personnel shall be qualified and certified according to the requirements of ASME XI, SNT-TC-1A, and LMT, Inc. Procedure QA-6, "Qualification and Certification of NDE Personnel."

VII. EQUIPMENT AND MATERIAL REQUIREMENTS

A. Ultrasonic testers shall be of the pulse echo type. Instruments shall have an amplitude display linear within 5% of calibrated screen height over 80% of that height, and an attenuator accurate over the range of the test to ±20% of nominal value which is stepped in increments of 2 dB or less. Instruments shall have had their internal

VII. A. alignment and calibration verified within 90 days of any implementation of this procedure.

1. A record of calibration shall be available at the jobsite for client audit.

B. Connecting cables shall be coaxial, and their length limited to less than that at which significant signal degradation occurs, but shall not exceed 200 feet.

C. Electronic recording equipment, when used, shall be electronically aligned within 180 days of use.

D. Search units shall be certified by the manufacturer as to essential properties, including bandwidth, damping, center frequency, and relative gain.

1. A record of search unit properties shall be available at the jobsite for client audit.

2. Angle beam search unit wedges shall be within $\pm 3^{\circ}$ of nominal value when checked on a standard reference block such as an IIW or Rompas.

3. Search units shall be selected according to Table 1. Additional search units may be used for evaluation or in unusual circumstances; however, such use shall be

VII. D. 3. documented by an approved Field Change to the procedure as per LMT, Inc. Quality Assurance Procedure QA-5.

Material Thickness	L-Wave Angle and Straight Beam Exam		Shear Wave Angle Beam Exam	
	Size (in.)	Freq.	Size	Freq.
¼" or less	¼"	5-10 MHz	¼"x¼"	5 MHz
>¼" to 1"	¼" to 1"	2¼-5 MHz	¼"x¼" to ½"x½"	2¼-5 MHz or 1-2¼ MHz P/C
1" and above	1"x1"	1-2¼ MHz	½"x½" to ½"x1"	2¼ MHz or 1-2¼ MHZ P/C

Table 1

4. Search unit contact angle beam wedges shall meet the requirements of Table 2 for coverage of the weld root as shown in Figure 1, when the examination is limited to half-node (half-vee path).

Beam Angle	Required Index to Weld ℄ Distance A
45°	.93T
60°	1.6 T
70°	2.47T

Table 2

VII. E. Couplant materials shall be as low as practicable in sulfur and halogen content. Certification shall be provided on a generic basis for each brand of couplant. Analysis for halogens and sulfur shall be made according to ASTM D-129-64 and ASTM D-808-63.

1. Residual halogens and sulfur shall not exceed 1% by weight.
2. Reactor coolant water is a satisfactory couplant.

F. Calibration blocks shall be of the form of Figures 2 and 3 with calibration notches as shown. Calibration blocks shall be of the same nominal size, thickness, material, and surface finish as the pipe to be examined.

1. Calibration notches for Class 1 piping examination shall be one inch long, less than ¼ inch wide, and 5% of the nominal pipe wall thickness in depth.
2. Calibration notches for Class 2 piping shall be one inch long, less than ¼" wide and 10% of the nominal pipe wall thickness in depth.
3. Calibration holes for use in half node examinations only shall be drilled perpendicular to the ends of

VII. F. 3. the block to the center line of the pipe, one and one - half inches deep. The hole diameters and location shall conform to those outlined in Table 3.

Pipe Wall (T)	Hole Ø	Hole Location
<2"	to be determined empirically	¼T and 3/4T
>2"	"	¼T, ½T, and 3/4T

Table 3

4. Other reflectors may be included in block designs for informational purposes.

VIII. <u>PREPARATIONS</u>

A. <u>Documentation</u>

1. The following documentation shall be submitted to the DAEC Supervisor for review before beginning any examination:

   a) Procedure

   b) Calibration Sheets

   c) Inspection Reports

   d) Materials and Equipment Certifications

VIII. A. 1. e) Personnel Certifications

f) NRC Form 4

g) NRC Form 5

B. Physical

1. The following physical preparation requirements shall be reviewed by the examiner with the DAEC Supervisor before specific examinations are performed:

   a) Insulation removal

   b) OSHA requirements (ladders, lighting, fresh air)

   c) Cleanup requirements

   d) Safety precautions

2. Surfaces shall be sufficiently smooth and clean that in the judgment of the examiner a meaningful examination may be performed, before proceeding.

3. Welds shall be identified and all required marking ~~procedures~~ completed before performing any examinations.

IX. LIMITATIONS

This procedure is based on ASME Nuclear Requirements; it may

IX. not be applicable to military, API, or AWS requirements without modification.

X. CALIBRATION

A. Test calibration is performed on a complete system. Any change in the ultrasonic instrument, transducer cable, or transducer requires test recalibration. A change in qualified personnel, recording instrumentation, or recorder connection cable requires a calibration check, however, instrument alignment verification need not be made with the transducer used for testing.

B. Instrument alignment verification for screen height and amplitude control linearity shall be performed before the initial examination in any given series and repeated at intervals not exceeding 90 days.

1. Instrument Linearity Verification

a) Position the search unit on a calibration block to obtain two echoes with a 2:1 amplitude ratio.

b) Set the larger echo to 80% of calibration screen height.

X. B. 1. c) Vary the amplitude of the larger echo from 100% to 20% of calibrated screen height in 10% increments.

d) Note that at each increment the smaller echo remains 1/2 the larger within a tolerance band of ±5% of full screen height.

e) Record successful performance of the verification on a Calibration Record form (Figure 4).

2. Attenuator Linearity Verification

a) Position the search unit to obtain an 80% of full scale echo on the calibrated screen.

b) Adjust the sensitivity control to decrease the system gain by 6 and 12 dB. Compare the response with Table 4 and determine its acceptability. Estimate system response to ±1% of calibrated full scale.

c) Position the search unit to obtain a 40% of full scale echo on the calibrated screen.

d) Adjust the sensitivity control to increase the system gain by 6 dB. Compare the response with

X. B. 2. d) Table 4 to determine its acceptability. Estimate system response to ±1% of calibrated full scale.

e) Position the search unit to obtain a 20% of full scale echo on the calibrated screen.

f) Adjust the sensitivity control to increase the system gain by 12 dB. Compare the response with Table 4 to determine its acceptability. Estimate system response to ±1% of calibrated full scale.

g) Record successful performance of the verification on a Calibration Record form (Figure 4).

Indication Set	Gain Change	Indication Tolerance Limits
80%	-6 dB	32% to 48%
80%	-12 dB	16% to 24%
40%	+6 dB	64% to 96%
20%	+12 dB	64% to 96%

Table 4

C. Examination Calibration

1. Straight beam examination scans shall be calibrated at the time of examination on a representative sample of the material examined by placing the first back

X. C. 1. reflection at 80% amplitude and four sweep divisions.

2. Angle Beam Examination

Calibration is performed on a complete system on an appropriate basic calibration block at the beginning of each day's testing of that material.

a) Calibration shall be performed on a calibration block whose temperature is within ±25°F of the material to be examined.

b) Set the sweep range on the calibrated tester screen according to Table 5.

Pipe Thickness (T)	Metal Path	I.D./O.D. Points
Up to ½"	2½ node	2,4,6,8,10 Div.
>½" - 1"	2 node	2.5,5,7.5,10 Div.
>1" - 2"	1½ node	3,6,9 Div.
>2"	1 node	5,10 Div.
Cast Stainless	½ node	8 Div.

Table 5

c) For examinations utilizing metal paths greater than one-half node, test sensitivity at any range is established by setting the amplitude of the

X. C. 2. c) nearest notch echo to 80% of full calibrated scale. The responses from the remaining notch echoes in the test region shall then be obtained at this sensitivity, joined together in a smooth DAC curve on the tester face, and similarly recorded on the Calibration Record form (Figure 4). The DAC curve so generated is the Primary Reference Level.

d) For examinations utilizing a half-node metal path, a DAC curve shall be generated using the side drilled holes in a basic calibration block so that the maximum hole response is set to 80% calibrated screen height. This response shall be obtained with the transducer centerline aligned with the hole half length and the beam perpendicular to the SDH, to prevent possible erroneous corner responses. The DAC shall be clearly marked on the tester face and smoothly extrapolated to cover the examination range 0 to T inches. The DAC shall also be recorded on the Calibration Record form (Figure 4). The DAC curve is the Primary Reference Level.

X. C. 2. e) After the Primary Reference Level has been established on the basic block a calibration reference response may be established on a Rompas or other standard reference block. The response should include both sweep and amplitude calibration points and should be recorded as a calibration check response on the Calibration Record form. This response may be used for calibration check when an appropriate basic block is not available.

XI. PERFORMANCE

A. Straight Beam Lamination Scan of Rolled Plate Piping

1. The area to be examined by angle beam methods shall be examined for laminations which would interfere with these examinations.

B. Calibration Check

1. A calibration check is required before and after each examination, with any change in test personnel, and at least once every four hours.

2. The calibration check shall as a minimum consist of

XI. B. 2. verification of the DAC curve by a single point amplitude and range check using the basic calibration block or a portable block such as the Rompas whose response has been related to that of the basic block.

a) The amplitude response of the reference reflector during the calibration check shall be within ±2 dB, and its sweep location within ±10% of the calibration reference response value recorded on the calibration sheet to be acceptable.

b) An unacceptable calibration check shall be cause for full examination of the test system to determine the reason for the calibration change. Typical causes for calibration change are ambient temperature effects on transducers and electronics, control settings inadvertently changed, and loss of couplant between the transducer and wedge. If, in the judgment of the examiner, the cause of the calibration change has been corrected or may be compensated for by a change in control settings, calibration may be restored using the calibration check response.

XI. B. 2. c) Any examination that has been performed in a non-calibrated condition shall be repeated.

C. <u>Sensitivity</u>

Scanning sensitivity shall be 6 dB greater than that of the Primary Reference Response.

D. <u>Coverage of Butt Welds in Piping</u>

1. The entire examination volume comprising the weld and adjacent base metal, as shown in Figure 5, shall be examined with the beam normal to the weld for at least a full V path on either side of the weld according to Table 6.

Beam	Required Perpendicular Scan Coverage Measured from the Weld ℄ for Full V with Weld Width T	Required Parallel Scan Coverage Measured from the Weld ℄
45°	The lesser of 3T or 2.5T+1"	T
60°	The lesser of 4.5T or 4T+1"	T
70°	The lesser of 6.5T or 6T+1"	T

Table 6

XI. D. 2. The entire examination volume comprising the weld and adjacent base metal, as shown in Figure 5, shall be examined with the beam parallel to the weld for a full V path on either side of the weld in two directions according to Table 6.

3. Any obstruction or other condition preventing full coverage of the examination shall be recorded on the examination report.

4. Overlap between parallel scans shall be nominally 15%, and in no case less than 10%.

E. Coverage for Branch Welds in Piping

Piping branch welds shall be examined from the larger pipe in both perpendicular and parallel directions to fulfill the coverage requirement of Table XI C. Examination volumes are shown in Figures 6, 7, and 8.

F. Scanning Speed

Scanning speed shall not exceed six inches per second.

G. Limitations

Physical or other limitations that prevent full compliance with the requirements of this procedure shall be recorded on the Examination Report form, Figure 6.

XI. H. Automatic Alarms

Automatic alarms or recording may be used as an aid to the examiner.

XII. EVALUATION

A. Reporting Criteria

1. Any indication exceeding 100% of the primary reference distance amplitude curve shall be evaluated by the examiner to determine the extent, location and shape of the reflector.

2. Reflector data shall be recorded and evaluated in terms of established acceptance criteria meeting paragraph IWA 3100 (b) of ASME XI (1974).

XIII. RECORDS

A. An Examination Report form shall be prepared for each item examined, and each Examination Report shall be related to an Ultrasonic Calibration Record. Typical forms are attached in Figures 4 and 9.

XIII. A. 1. The Examination Report shall contain a sketch which clearly identifies the location reference system for the examination.

2. Where permanent reference marks are available, locations shall be measured according to the direction of the reference mark.

a) Should no permanent reference marks be available, the location reference system shall utilize clock coordinates with 12:00 o'clock reference to top dead center on horizontal piping and the outside radius of the nearest elbow on vertical piping. Branch piping welds are to be referenced according to the branch.

B. Oscillograph chart records may be made of all examinations.

1. Chart records used in indication analysis shall utilize two channels, one corresponding to vertical deflection of the tester signal and the other to horizontal.

a) These channels shall be calibrated to match the oscilloscope display. That is, an indication 90% of vertical amplitude appearing at five divisions on the tester screen should have a nine division

XIII. B. 1. a) deflection on one chart channel and a five division deflection on the other.

2. Chart records may include pre and post test calibration checks made at the same scanning speed as the test.

3. Location and other pertinent information shall be manually noted on each chart.

a) Pertinent information includes, but is not limited to date, time, item, equipment, examiners, scans, recorder settings and speed.

C. Recording Conventions

1. Ultrasonic scans and the location of indications shall be recorded according to the convention established.

D. Other types of recording, such as event or alarm monitoring, may be used as an aid to the examiner where feasible.

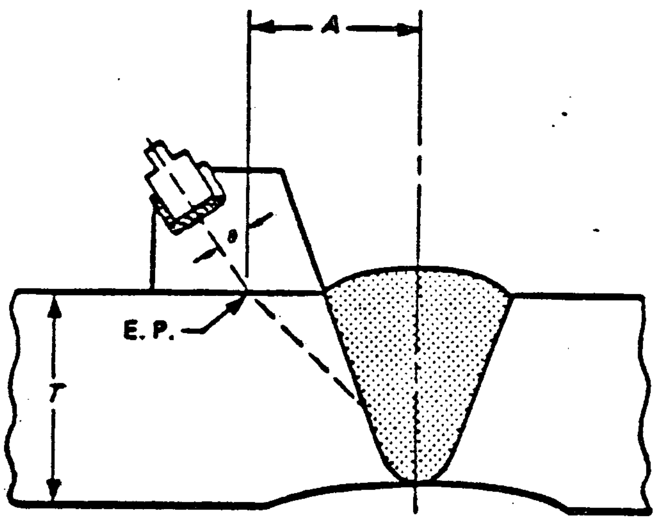
XIV. REVIEW

Examination Reports are subject to review by the assigned LMT Level III Examiner for conformity to the requirements of this procedure.

XV. STORAGE AND DISTRIBUTION

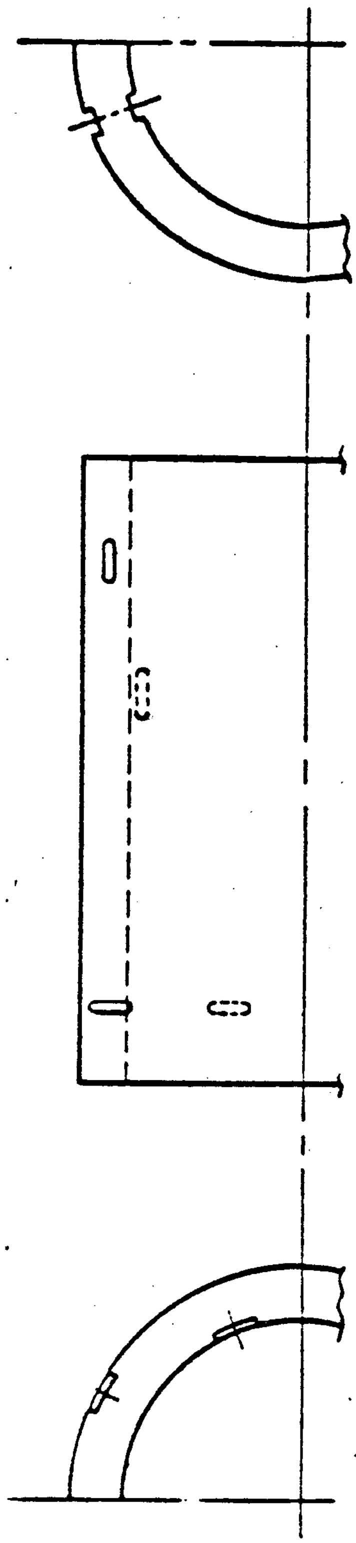
A. Examination documentation shall become the property of IELP upon sign-off. Additional reports, which may include examination documentation as reference material, shall be generated from copies.

B. Field storage facilities shall provide a safe storage area, and access to files shall be limited to the LMT Field Supervisor and his designated representatives, the DAEC Supervisor, and the Authorized Nuclear Inspector.



WELD COVERAGE

Figure 1

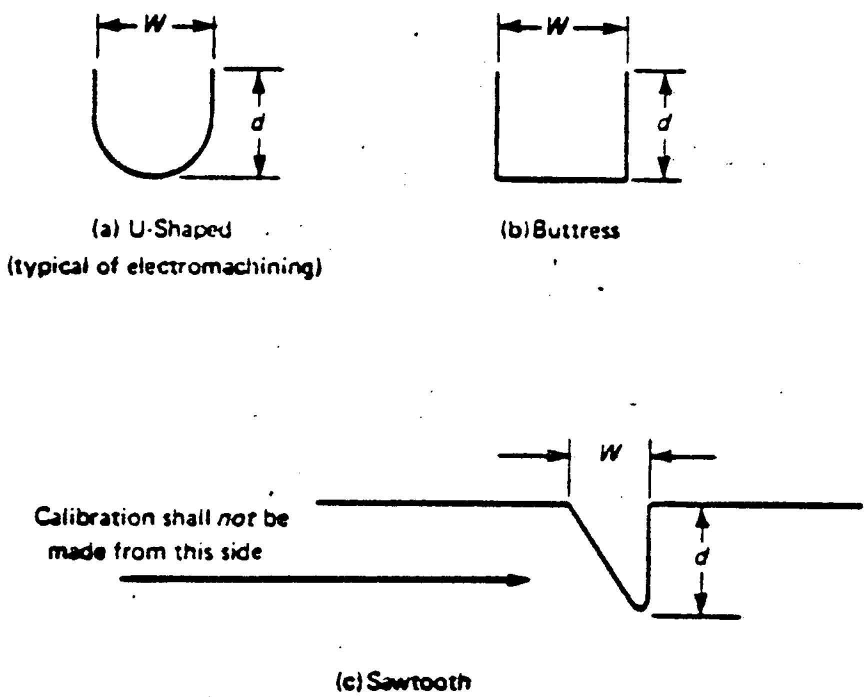


UT CALIBRATION BLOCK DESIGN FOR PIPING
ILLUSTRATIVE ONLY

Figure 2

Lambert • MacGill • Thomas, Inc.
Testing • Engineering • Service • Training
771 East Brokaw Road
San Jose, Ca. 95112
408-297-8766

ACCEPTABLE REFLECTORS



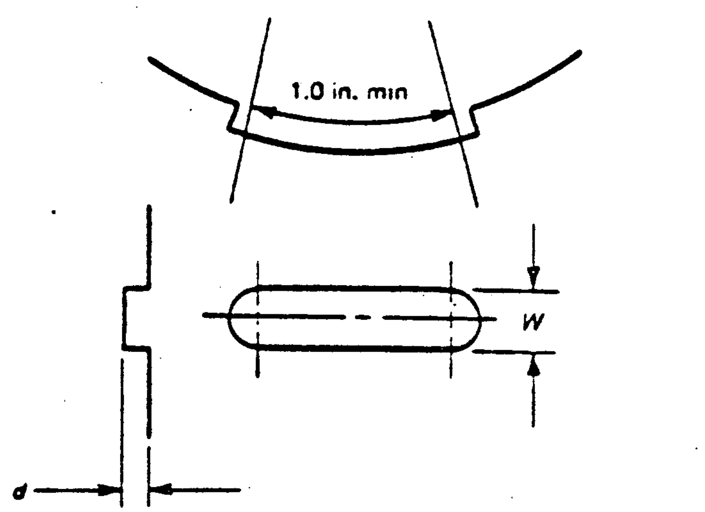


Figure 3

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408-297-8766

ISO No. ______
Cal. No. ______ Time ______
Job No. ______
Date ______
Page ______ of ______

REPORT OF ULTRASONIC CALIBRATION

SIGN

Examiner/Level ______ Examiner/Level ______ Review/Level ______
Authorized Inspector ______ Customer ______

EQUIPMENT

Instrument ______ S/N ______ Recorder ______ S/N ______
Recorder ______ S/N ______ Cable ______

Vertical Linearity Check Check Completed ______

Signal 1	100	90	80	70	60	50	40	30	20	10
Signal 2										

Signal 2 shall equal 50% of Signal 1 ±5% of full scale

Attenuator Linearity Check Check Completed ______

Tester Gain	Set	-6	-12	Set	+12	Set	+6
Signal Amp.	80%	32 to 48	16 to 24	20%	64 to 96	40%	64 to 96
Actual Value	▨			▨		▨	

Signal amplitude must fall within listed values

Transducers

S/N ______ Mfg. ______ Type ______ Size ______ Freq. ______ Index ______ Angle ______
S/N ______ Mfg. ______ Type ______ Size ______ Freq. ______ Index ______ Angle ______
S/N ______ Mfg. ______ Type ______ Size ______ Freq. ______ Index ______ Angle ______
S/N ______ Mfg. ______ Type ______ Size ______ Freq. ______ Index ______ Angle ______

PROC

Procedure ______ Rev. ______ Date ______

CALIBRATION

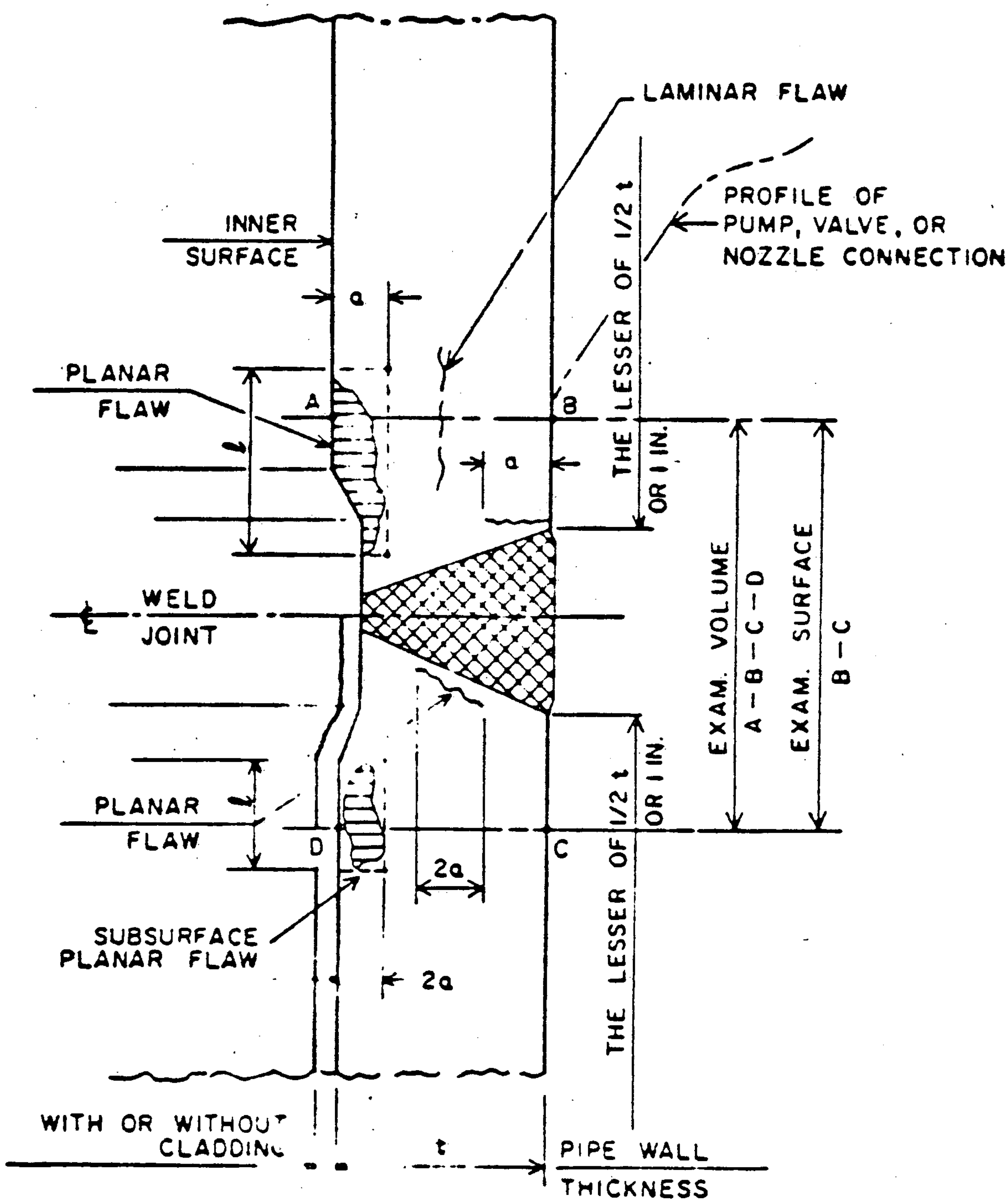
Cal. Block Type ______ S/N ______ Ref. Refl. ______ Temp. ______
Verification/Ref. Blk. ______ S/N ______ Ref. Refl. ______ Temp. ______

Instrument Settings			
	L	∠	
Gain			
Sweep			
Delay			
Reject			
Damp.			

DAC

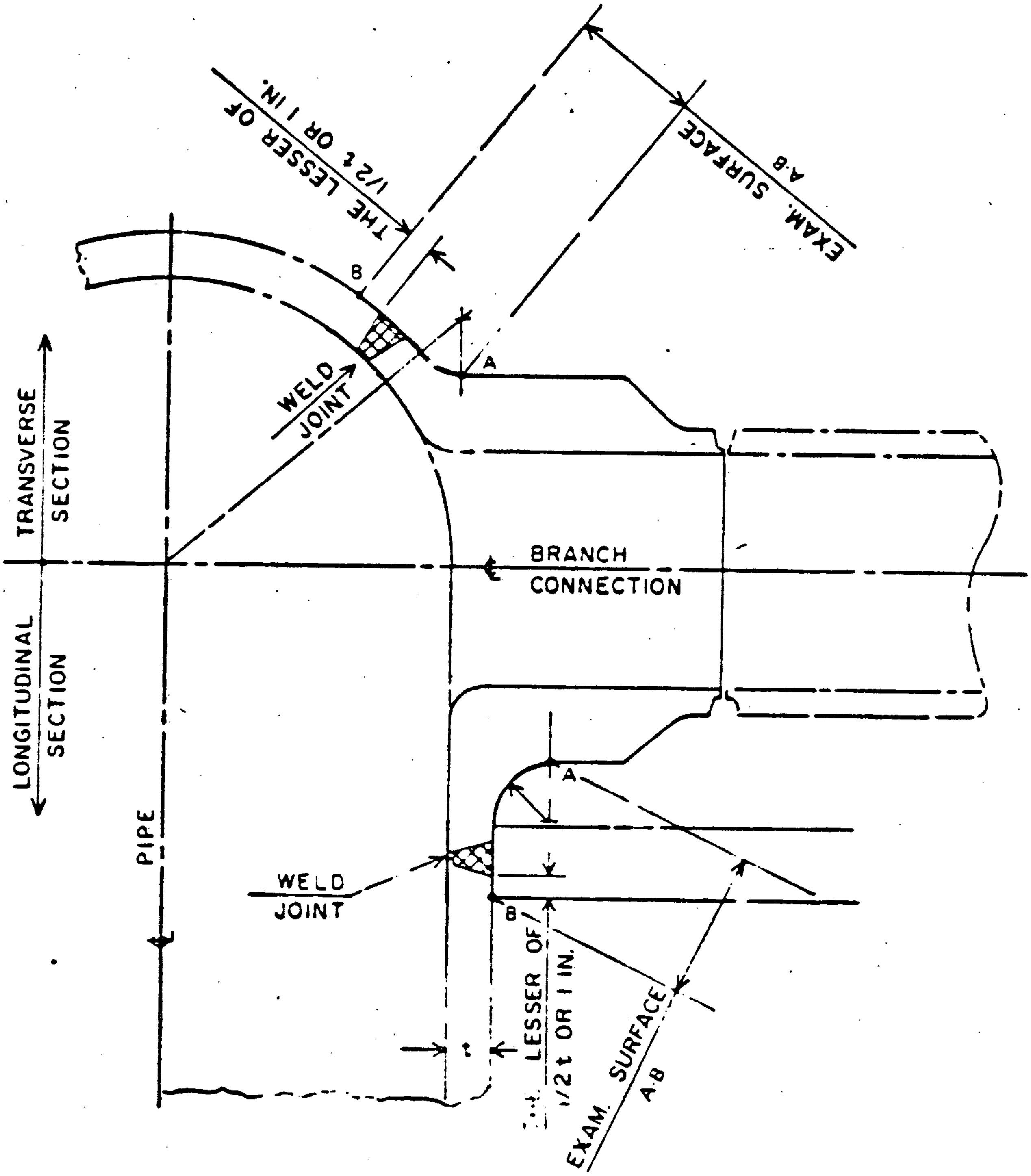
10
8
6
4
2
0
2 4 6 8 10

Cal. Check Time

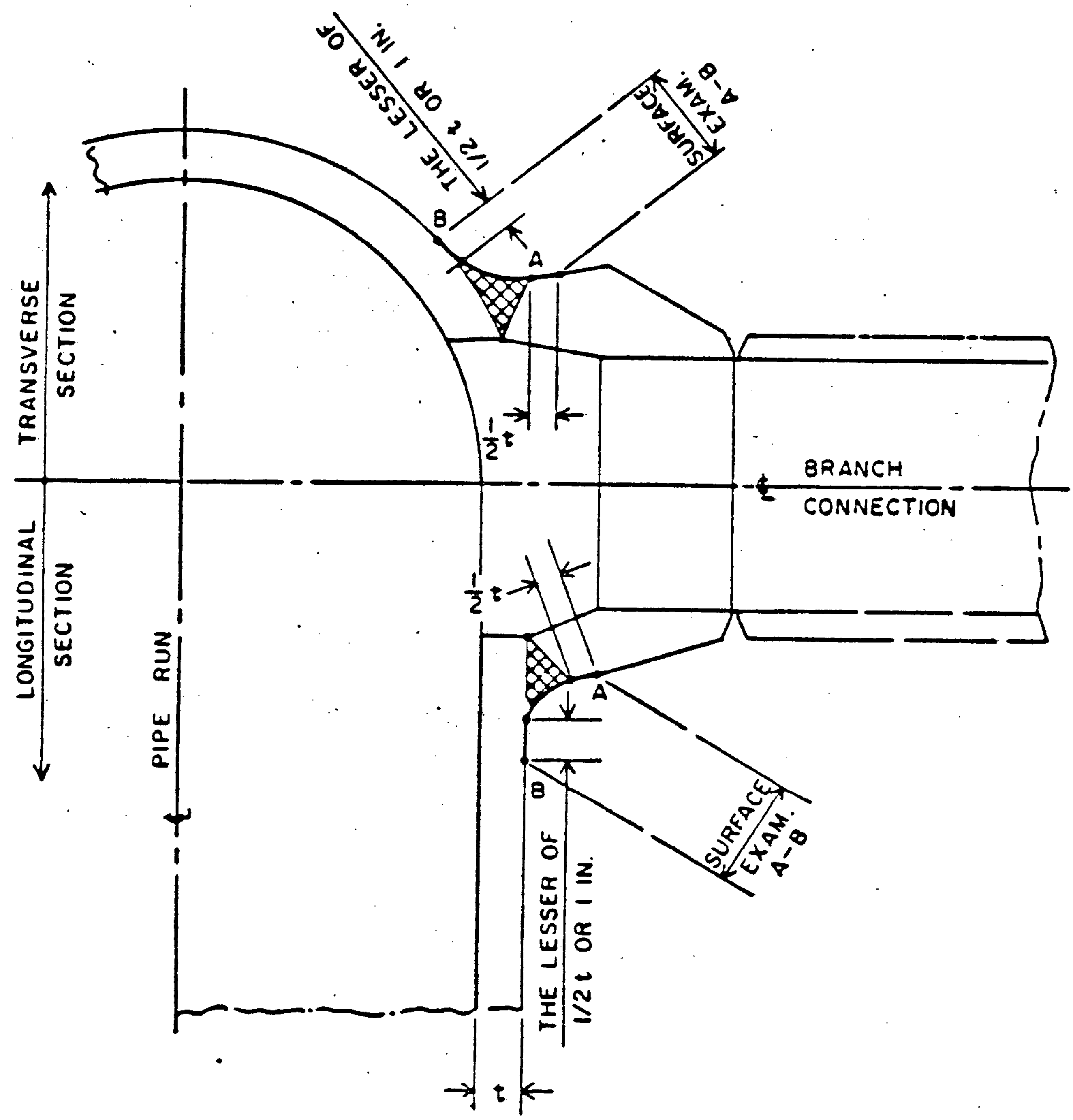


PIPE WELD EXAMINATION VOLUME

Figure 5

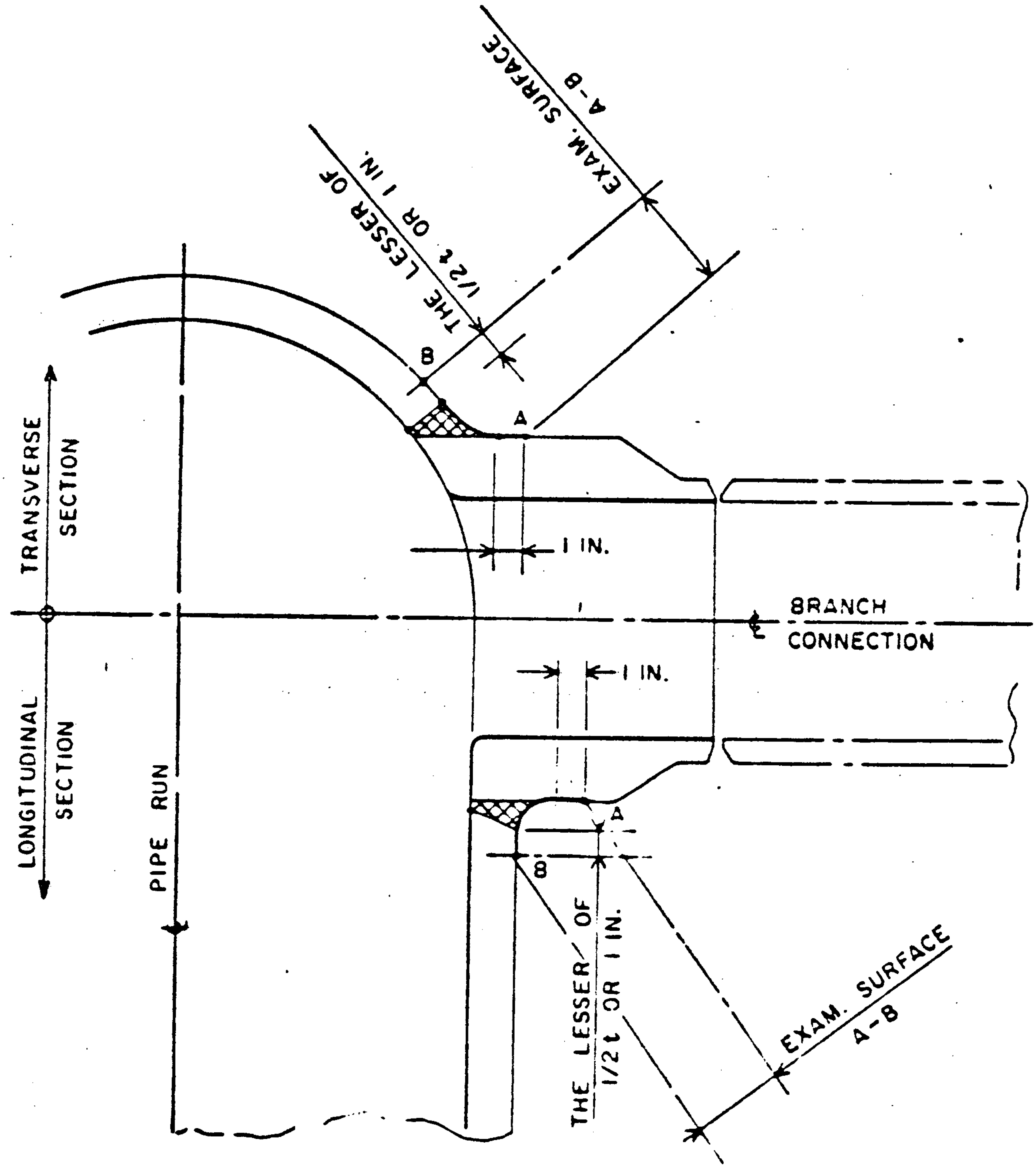


TYPE 1 BRANCH WELD
EXAMINATION VOLUME
Figure 6



TYPE 2 BRANCH WELD
EXAMINATION VOLUME

Figure 7



TYPE 3 BRANCH WELD
EXAMINATION VOLUME
Figure 8

LMT-UTX2 3/77

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San Jose, Ca. 95112
408-297-8766

Location ______
Report No. ______
Cal.No. ______ Time ______
Job No. ______
Date ______
Page ______ of ______

REPORT OF VISUAL AND ULTRASONIC EXAMINATION

ITEM

Description ______ Size ______ Material ______ S/N(s) ______

Location ______ Preparation ______ Temp. ______

SIGN

Examiner/Level ______ Examiner/Level ______ Review/Level ______

Authorized Inspector ______ Customer ______

EQUIPMENT

Tester 1 ______ S/N ______ 2 ______ S/N ______

Recorder 1 ______ S/N ______ 2 ______ S/N ______

Transducer 1 ______ 2 ______

3 ______ 4 ______

Couplant ______ Cable ______ Marker ______ Photo ______

PROC

Calibration Procedure ______ Rev. ______

Examination Procedure ______ Rev. ______

Record Procedure ______ Rev. ______

CALIB

Calib. Blk. ______ Temp. ______ Ref. ______ Amp. ______ Swp. ______

Ref. Gain ______ Damp ______ Reject ______ Gate ______

Alarm ______ Mag. Tape Count ______ Chart ______ Cal. Check Time ______

EXAMINATION

Cal. Ref. Blk. ______ Ref. Rfl. ______ Amp. ______ Sweep Position ______

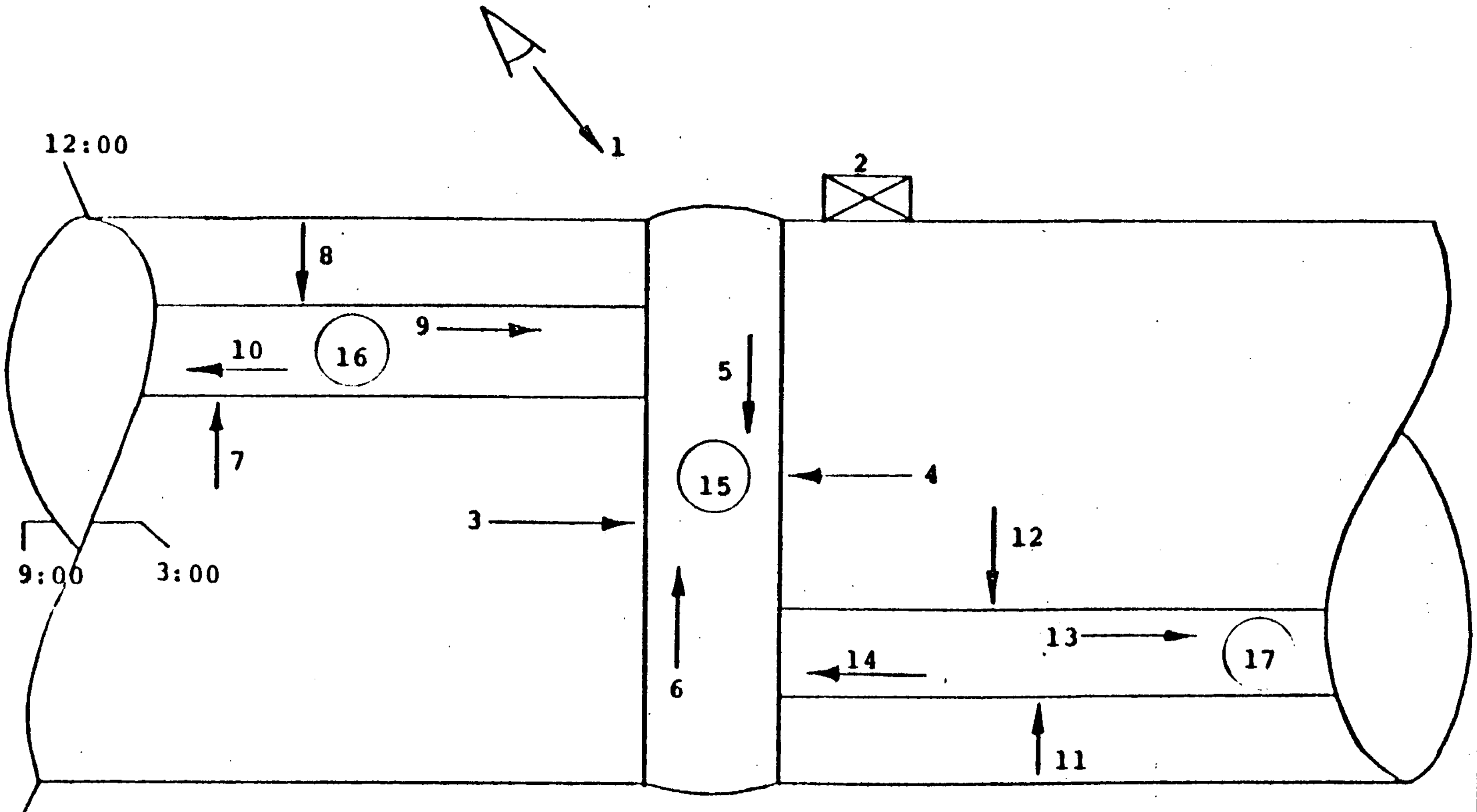
Scan Gain ______ Ref. Dwg. ______ Reject Level ______ Report Level ______

NAD = No apparent disc. L = Linear G = Geometry S = Spot M = Multiples

Scan	Type	Disp.	Scan	Type	Disp.	Scan	Type	Disp.
0	PT							
1	Visual		7			13		
2	Base Metal		8			14		
3			9			15		
4			10			16		
5			11			17		
6			12			18		

Scan	Description of Indications

Figure 9



Reference Arrow

(Toward next highest weld number)

1	Visual
2	Base Metal (when required)
3-14	Angle Beam
15-17	0° Weld and HAZ (when required)

MANUAL SCAN DIRECTIONS

Figure 10

Lambert • MacGill • Thomas, Inc.
Testing • Engineering • Service • Training
771 East Brokaw Road
San Jose, Ca. 95112
408-297-8766

ATTACHMENT 4

Iowa Electric Light and Power Company

December 1, 1982
NG-82-2653

LARRY D. ROOT
ASSISTANT VICE PRESIDENT
NUCLEAR GENERATION

Mr. James G. Keppler
Regional Administrator
Region III
U.S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Response to IE Bulletin 82-03, IGSCC

Dear Mr. Keppler:

This letter and attachments are submitted in response to your IE Bulletin 82-03, Revision 1, issued October 28, 1982. In accordance with your request, this letter provides response to those items in your Bulletin for which you requested information by December 1, 1982. Additional information will be developed prior to and during the DAEC Cycle 7 refueling outage which is currently scheduled to begin on February 11, 1983. This additional information will be forwarded to you as it is developed.

Attachment 1 responds on an item by item basis to IEB-82-03. For convenience, we have also reproduced the questions and requests for information of your Bulletin. Four additional attachments are provided which contain detailed information.

Preparation and submittal of this letter and information to the NRC is estimated to have required approximately three man weeks of engineering effort. Estimates of resources that will be devoted to preparing future submittals will be provided in subsequent correspondence.

In accordance with your request, this letter and attachments are submitted under oath and affirmation.

IOWA ELECTRIC LIGHT AND POWER COMPANY

BY Philip [signature] for
Larry D. Root

LDR/WJM/dmh*
Attachments

Subscribed and sworn to Before Me on this 1st day of December 1982.

Mary E. Benfield
Notary Public in and for the State of Iowa

MARY E. BENFIELD
COMMISSION EXPIRING
SEPTEMBER 30, 1983

cc: W. Miller
D. Arnold
L. Liu
S. Tuthill
F. Apicella
NRC Resident Office
Ref: Commitment Control No. 82-0434

ATTACHMENT 1

IEB 82-03 Item 1

Actions To Be Taken by Licensees of BWR Facilities Identified in Table 1:

1. Before resuming power operations following the current refueling or extended outage, the licensee is to demonstrate the effectiveness of the detection capability of the ultrasonic methodology used or planned to be used to examine welds in recirculation system piping. This demonstration shall be made on representative service-induced cracked pipe samples. Arrangements should be made to allow NRC to witness this demonstration. This demonstration shall employ those procedures and standards, the same type of equipment (same transducer size, frequencies and calibration-standards), and representative UT personnel from the inservice inspection (ISI) organization utilized or to be utilized in the examinations at the plant site.*

Response to Item 1

The Level III Inspector that DAEC will utilize for the Cycle 7 DAEC refueling outage inspections is Mr. Elwin L. Thomas of the firm of Lambert, Macgill and Thomas. Mr. Thomas has previously demonstrated on behalf of Northeast Utilities the effectiveness of UT methodology that is functionally equivalent to that to be employed at DAEC. This demonstration was conducted at the Battelle Memorial Institute in Columbus, Ohio and included samples of the Nine Mile Point Unit 1 Plant. It is our understanding that representatives of the NRC were present to witness this demonstration.

It is our intent not to repeat the demonstration by Mr. Thomas. In the event the NRC believes a repeat of this demonstration is necessary, we request prompt notification to allow scheduling of a demonstration that will avoid impacting the DAEC refueling schedule.

IEB 82-03 Item 2

2. Before resuming power operations following the current refueling or extended outage, the licensee is to provide a listing of results of recirculation system piping inspections.

Response to Item 2

The requested information will be provided prior to resuming power operations following DAEC Cycle 7 refueling outage.

---

*We understand that Electric Power Research Institute (EPRI) has arranged to have samples from the Nine Mile Point Unit 1 plant available for industry demonstrations of UT methodology. The samples have been taken to Battelle Memorial Institute in Columbus, Ohio for characterization and subsequent use.

IEB 82-03, Item 3

3. Before resuming power operations following the current refueling or extended outage, the licensee (if the inspections indicate the presence of cracks) is to describe the corrective actions taken and report these in accordance with the appropriate regulations.

Response to Item 3:

The requested information will be provided prior to resuming power operations following DAEC Cycle 7 refueling outage.

IEB 82-03, Item 4a

4. To assist NRC's further evaluation of this issue, the following shall be submitted by December 1, 1982:

   a. A description of the sampling plan used or to be used during this outage for UT examinations of recirculation system piping welds and the bases for the plan. The description should:

      (1) Provide an isometric drawing of the recirculation system piping showing all the welds, and the number of welds and their locations that have been examined or will be examined.

      (2) Identify criteria for weld sample selection (e.g., stress rule index, carbon content, high stress location, and their values for each weld examined).

      (3) Describe piping material(s), including material type, diameter, and wall thickness.

      (4) Estimate the occupational radiation exposure incurred or expected and briefly summarize measures taken to maintain individual and collective exposures as low as reasonably achievable.

Response to Item 4a:

(1) Attachment 2 contains isometric drawings of the DAEC recirculation system and a matrix of prior and scheduled weld inspections for the DAEC Cycle 7 refueling outage.

(2) Criteria for weld sample selection for all recirculation system welds that have been examined since the 1980 refueling outage and those welds to be examined during the 1983 outage have been based upon stress rule index and carbon content. In addition to the above, all welds in these recirculation system bypass loops have been examined during each refueling outage since 1975. Also, all welds in the recirculation inlet risers will have been examined once and more than

fifty percent of the riser welds will have been examined a second time with the 1983 outage examinations. The isometric drawings and IGSCC Susceptibility Matrix (Attachment 2) identifies all welds and the year of the latest examination. Also, the Stress Corrosion Cracking Evaluation Program Report - Duane Arnold Energy Center; dated April 23, 1980 (Attachment 3) identifies the carbon content of material and the stress rule index for each weld.

(3) Attachment 3 identifies each component in the recirculation system by size and material specification and type. The main loop piping is 22 inch O.D. Schedule 80 pipe and fittings.

The ring headers are nominal 16" O.D. with nominal thickness of 1 and 1/8". The header cap is 16" O.D. with a minimum wall thickness of 0.708". The inlet risers are 10" schedule 80 nominal size pipe and the bypass loops are 4" Schedule 80 nominal pipe size.

(4) The estimated occupational exposure for personnel involved in preparing for scheduled recirculation system inspections (insulation removal for example), conducting inspections, and restoring the piping systems to pre-inspection status is 37 man rems. This calculation does not include exposure that would be incurred in the event any repairs are warranted.

The primary means that will be utilized to limit occupational dose is: (a) the installation of temporary shielding blankets and (b) limiting worker time in radiation fields. Based on past experience, installation of heavy shielding or internal systems decontamination are not judged to be cost effective or effective in dose reduction due to increased exposure to install heavy shielding or to decontaminate systems.

<u>IEB 82-03, Item 4b</u>

b. A summary description of the UT procedures and calibration standards used or to be employed in the examination at the licensee's plant site. This description should include the scanning sensitivity, the evaluation sensitivity and the recording criteria.

<u>Response to Item 4b:</u>

Iowa Electric plans to use Ultrasonic Procedure #UT-27 Revision 0 with field changes in our next refueling outage. This procedure has successfully detected cracks at Duane Arnold in 4" schedule 80 pipe which was verified by Dye Penetrant Test after pipe removal. A description of #UT-27 Revision 0 is as follows:

(1) The primary reflection is <u>5%</u> notchs for Class 1 piping.

(2) Evaluation sensitivity is established by setting the nearest notch echo to 80% of full calibrated scale.

(3) Scanning sensitivity shall be 6 db greater than the primary response.

(4) A calibration check is required before and after each examination.

(5) Examiners must be certified at a minimum as Level II in Ultrasonic Testing to evaluate results and subsequent review and evaluation by Level III, will be provided.

(6) Evaluation is in accordance with IWA 3100 (b) of ASME Section XI (1974) with addenda through Summer, 1975. Iowa Electric plans to continue its policy of recording any indication determined to be a crack regardless of amplitude or size.

(7) Strip chart recordings are planned for recording shear wave results.

(8) All recorded chart signals shall be identified.

(9) Calibration blocks shall be of the same nominal size, thickness, material, and surface finish as the pipe to be examined in the 1983 outage.

IEB 82-03, Item 4c

c. A summary of the results of any previous inspection of the recirculation system piping welds which used the validated examination methodology as discussed in Action Item 1 above.

Response to Item 4c:

Attachment 4 summarizes the results of 1981 and 1982 recirculation system inspections. These inspections were conducted with functionally equivalent UT examination techniques as is discussed in the response to items 1 and 4b, above.

IEB 82-03, Item 4d

d. An evaluation of the crack-detection capability of ultrasonic methodology used or planned to be used to examine recirculation system piping welds. This evaluation should result from conducting the demonstration required in Action Item 1 above, and should include a comparison of the service-induced pipe crack sample to those welds actually examined in the licensee's plant in terms of pipe wall thickness and diameter, weld geometry, and materials.

Response to Item 4d:

The requested information will be provided in a future submittal prior to DAEC resuming power operations following Cycle 7 refueling outage.

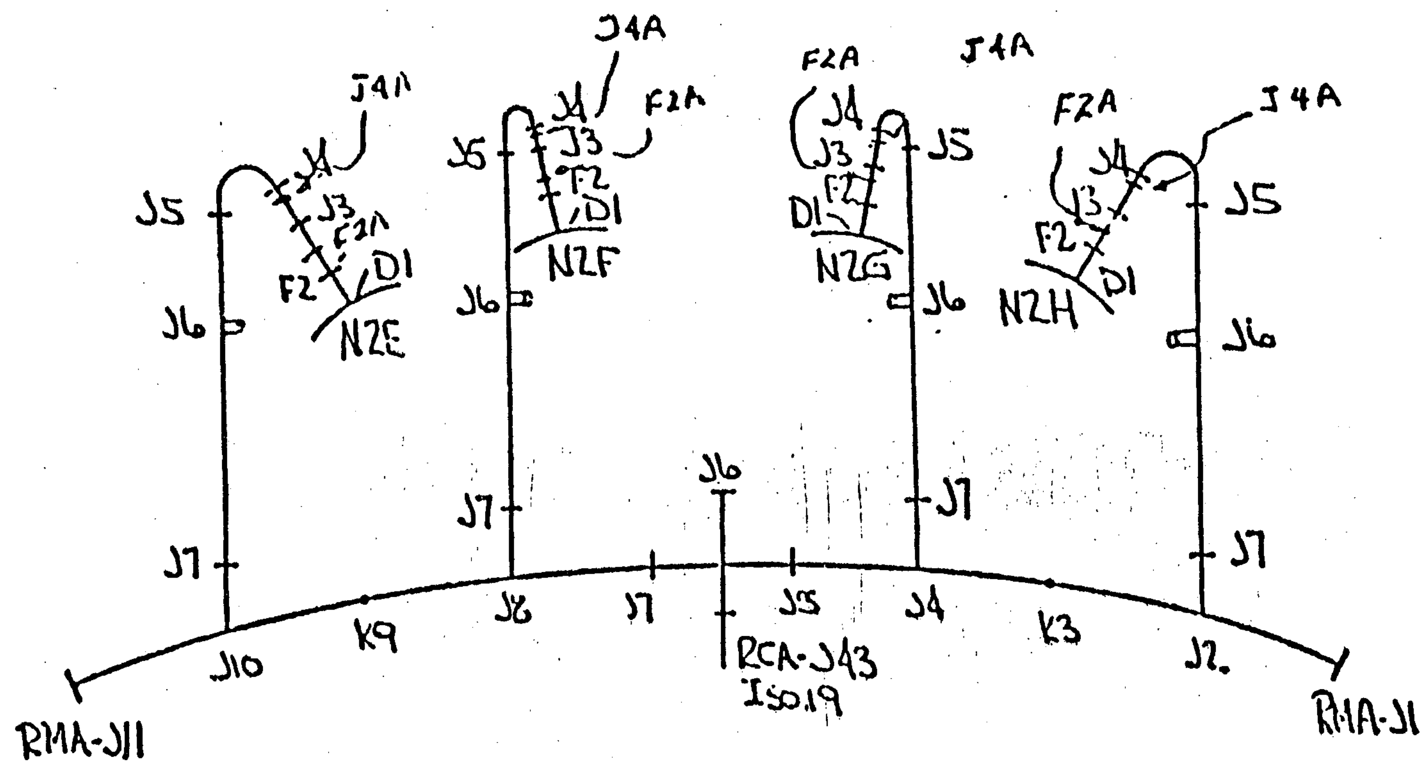
ATTACHMENT 2

STRESS RULE INDEX (columns) / **CARBON CONTENT (%)** (rows)

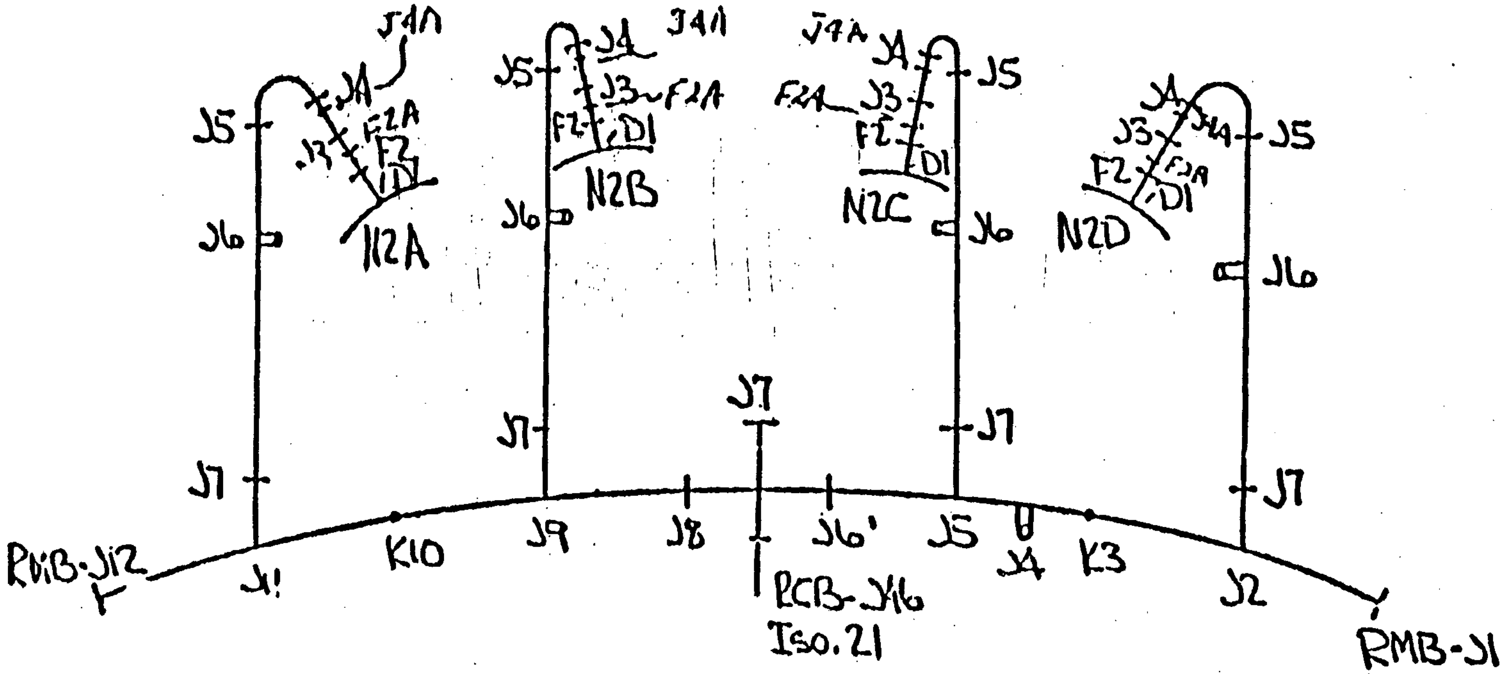
CARBON CONTENT (%)	0 - 1.20	1.21 - 1.50	1.51 - 2.00	2.0
.070 +	RRA-J7 (5,7) RRD-J7 (5) RRE-J7 (3) RRF-J7 (5) RRH-J7 (5)	RCA-J18 (7) RMA-J10 (5) RRG-J7 (5) RCB-J21 (5) RRB-J7 (5) RRC-J7 (5)	RMA-J4 (5) RMA-J2 (5) RMB-J11 (5) RMB-J2 (5)	RMA-J8 (5) RMB-J5 (5) RMB-J9 (5)
.060 - .069	RCA-J27 (5) RBA-J7* (5) RCB-J30 (5) RHC-F2 (7) RHD-F2 (2)	RCA-J34 (5) RBA-J1* (5,7) RRE-J4 (6) RRF-J4 (6) RRC-J4 (6,7) RRD-J4 (5,7) RCB-J3 (5) RBB-J1* (5) RBB-J7* (5) RBB-J12* (5,7) RHC-J1 (7) RHD-J1 (2)	RRA/H-J5 (8 WELDS)(5) RBA-J6* (5,7) RBA-J8* (5,7) RRG-J4 (5,7) RRH-J4 (5,7) RRA-J4 (6) RRB-J4 (6) RBB-J6* (5,7) RBB-J8* (5,7)	REGION III (HIGH SUSCEPTIBILITY)
.050 - .059	RCA-J7 (7) RCA-J15 RCA-J24 (4) RCA-J28 (3) RCA-J38 RMA-J1 RMA-J11 (3) RRA/H-J4A (8 WELDS) ├A,B,E,F (6) └C,D,G,H (5,7) RCB-J27 (4) RCB-J31 (3) RCB-J41 RMB-J1 RMB-J12 (3) RHB-J1 (1)	RCA-J12 (1) RCA-J13 (1) RCA-J21 (4) RCA-330 (7) RCA-J32 (7) RCA-J41 (7) RCA-J43 (7) RMA-J6 (7) RMA-J5 (7) RMA-J7 (7) RBA-J2 (5) RBA-J3 (5) RCB-J6 (7) RCB-J7 (7) RCB-J33 (7) RCB-J35 (3,7) RCB-J24 (7) RMB-J7 (7) RMB-J6 (7) RMB-J8 (7) RBB-J2* (5) RBB-J3* (5) RRA/H-J3 (8 WELDS) ├A,B,E,F (6) └C,D,G,H (5,7)	RBA-J9* (5) RBB-J9* (5)	
.035 - .049	RCA-J3 (1) RCA-J6 (1) RCB-J3 (1) RCB-J9 (1) RCB-J18	RCA-J4 (1) RCA-J5 (1) RBA-J12* (5,7) RCB-J4 (1) RCB-J5 (1) RCB-J15 (1) RCB-J16 (1) RCB-J24 (7) RCB-J46 (2)	RCA-J22 (4) RBA-J10* (5) RCB-J25 (7) RBB-J10* (5) REGION III (MODERATE SUSCEPTIBILITY)	
<.035	RHB-F3 (1) RCA-F2 (1) RCB-F2 (1) RRA/H-F2A (8 WELDS) ├A,B,E,F (6) └C,D,G,H (5,7)		REGION I (LOW SUSCEPTIBILITY)	

NOTES

- * In Service Sensitive Lines
- xxx Shop Water Sprayed Cooled
- (1) Last examination in 1976
- (2) Last examination in 1977
- (3) Last examination in 1978
- (4) Last examination in 1980
- (5) Last examination in 1981
- (6) Last examination in 1982
- (7) Scheduled for 1983 Refuel Outage

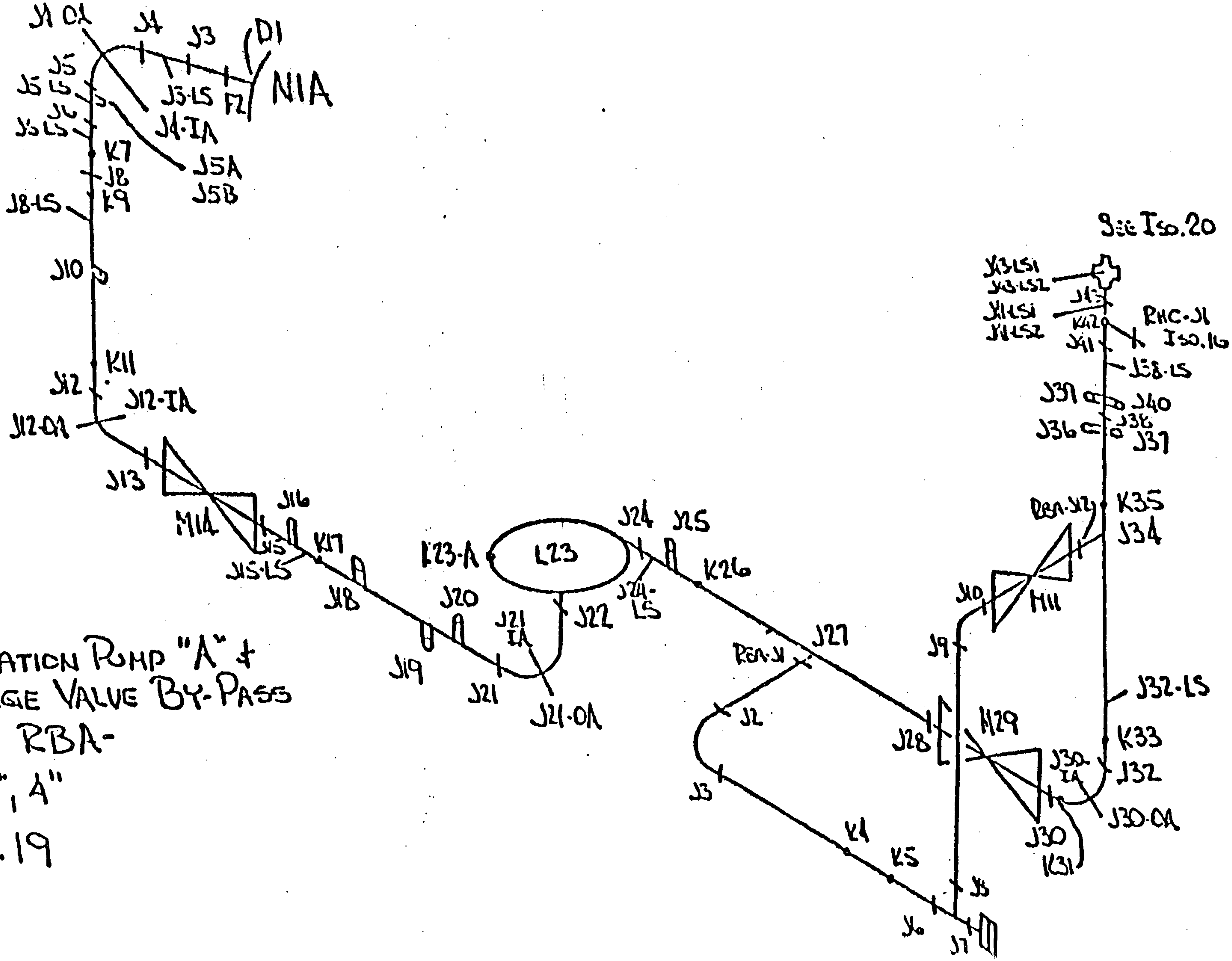


Recirculation Manifold "A" & Risers E, F, G, H
RMA-, RRE-, RRF-, RRG-; RRH-
SS, 16", 10"
Iso. No. 20

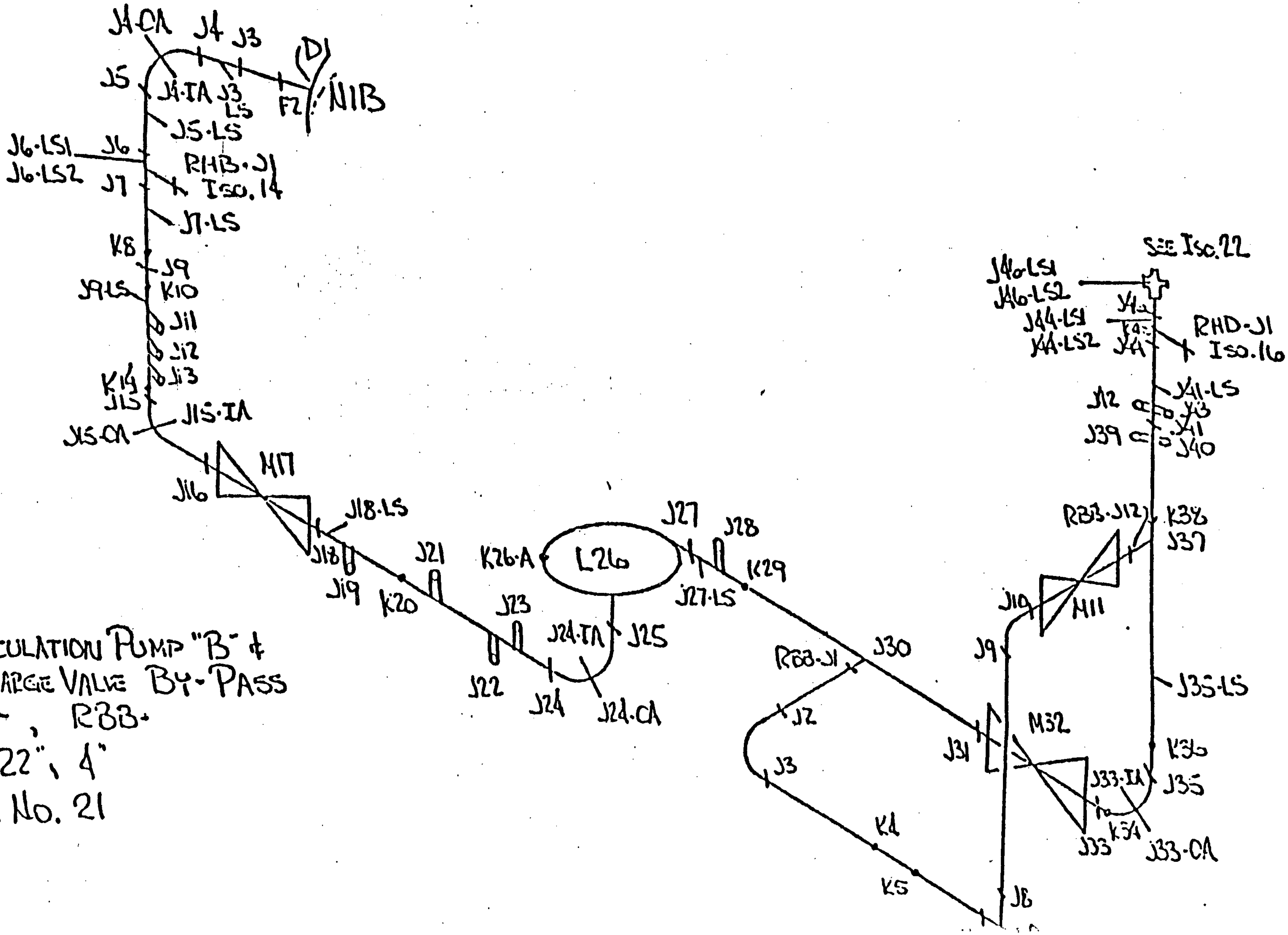


RECIRCULATION MANIFOLD "B" & RISERS A, B, C, D
RMB-, RRA-, RRB- RRC-, RRD-,
SS, 16", 10"

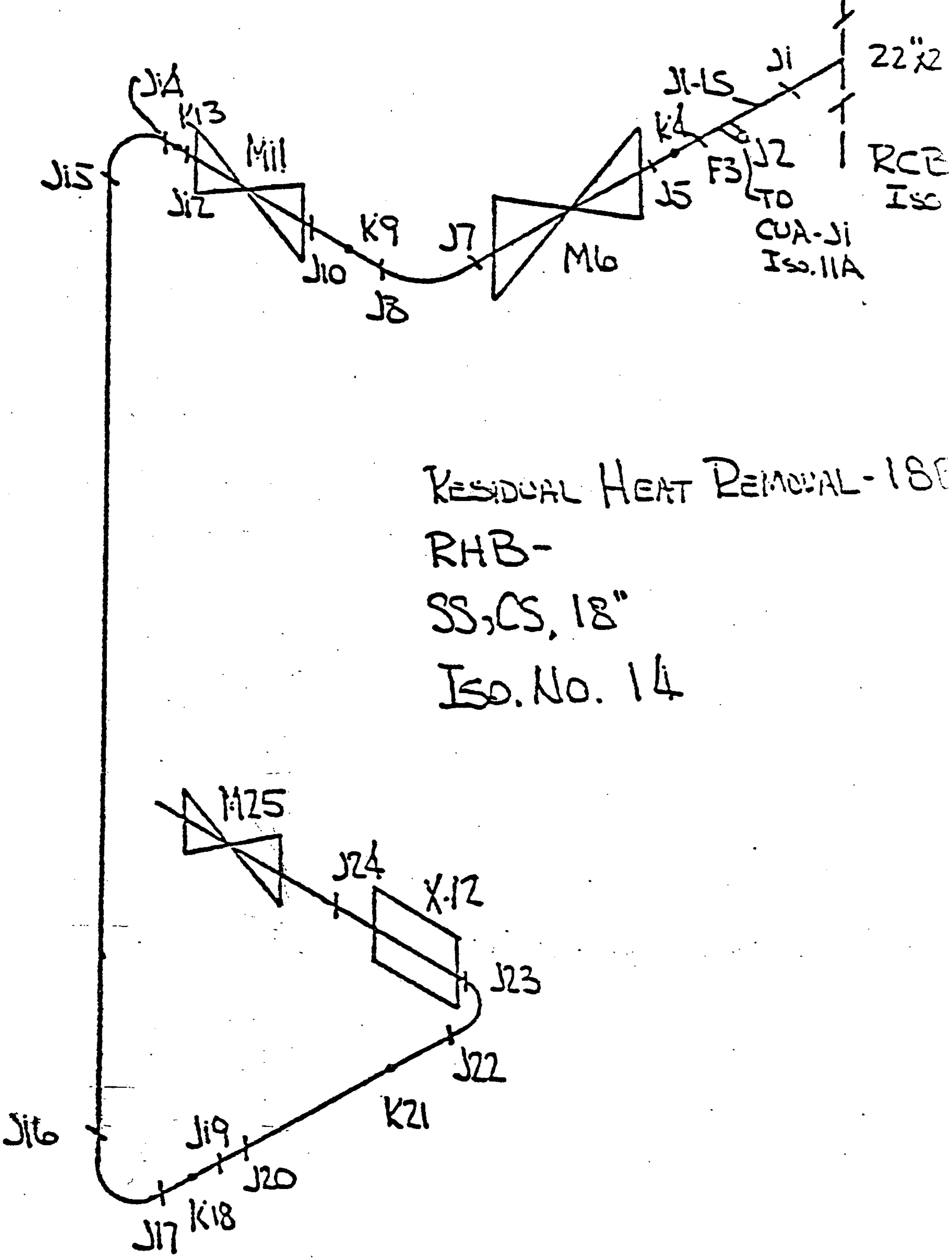
ISO. NO. 22



CIRCULATION PUMP "A" &
SCHARGE VALVE BY-PASS
A-, RBA-
S, 22", 4"
ISO. No. 19



CIRCULATION PUMP "B" &
SCHARGE VALVE BY-PASS
CB- , RBB-
3, 22", 4"
SO. NO. 21



Residual Heat Removal-18

RHB-

SS, CS, 18"

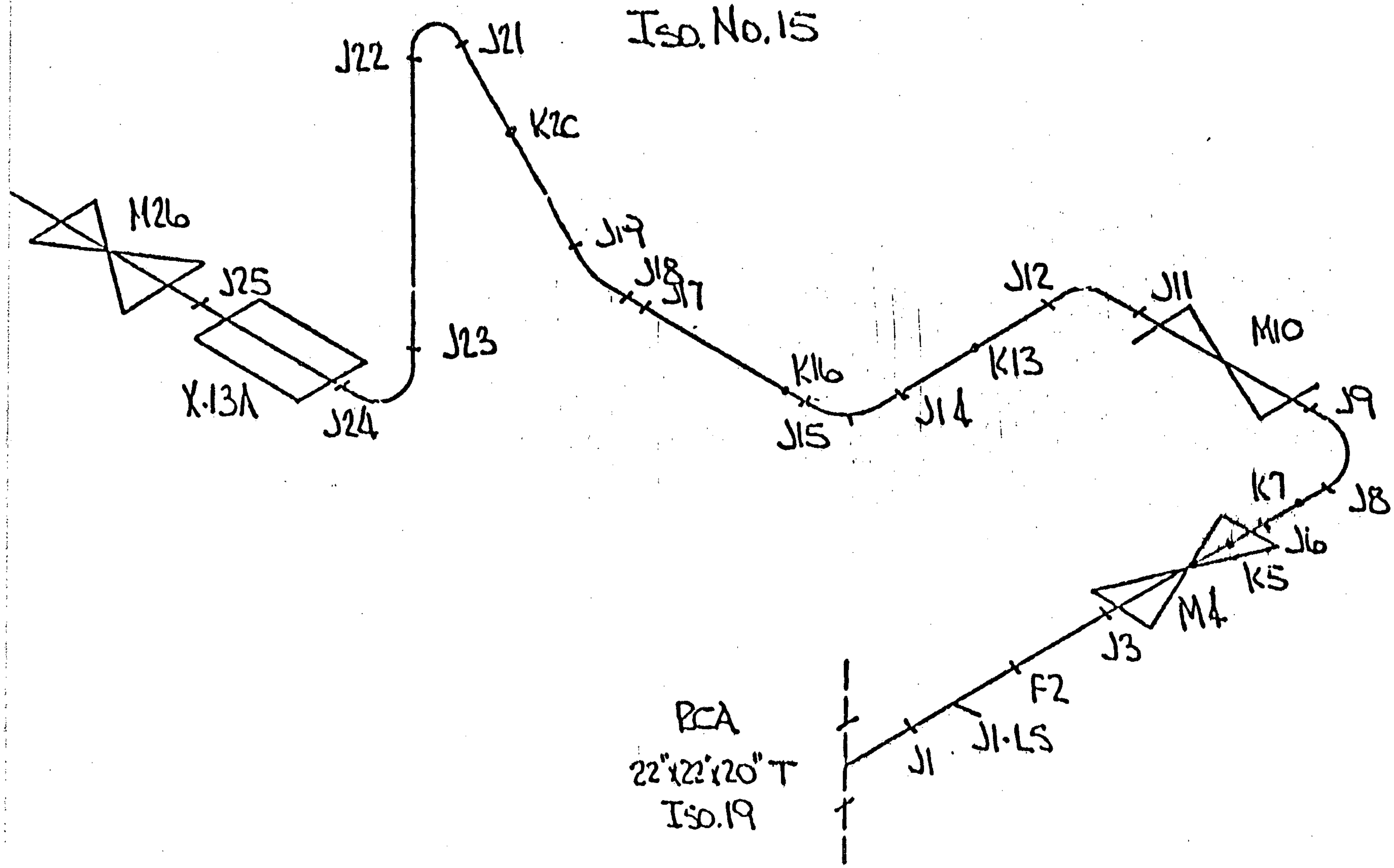
Iso. No. 14

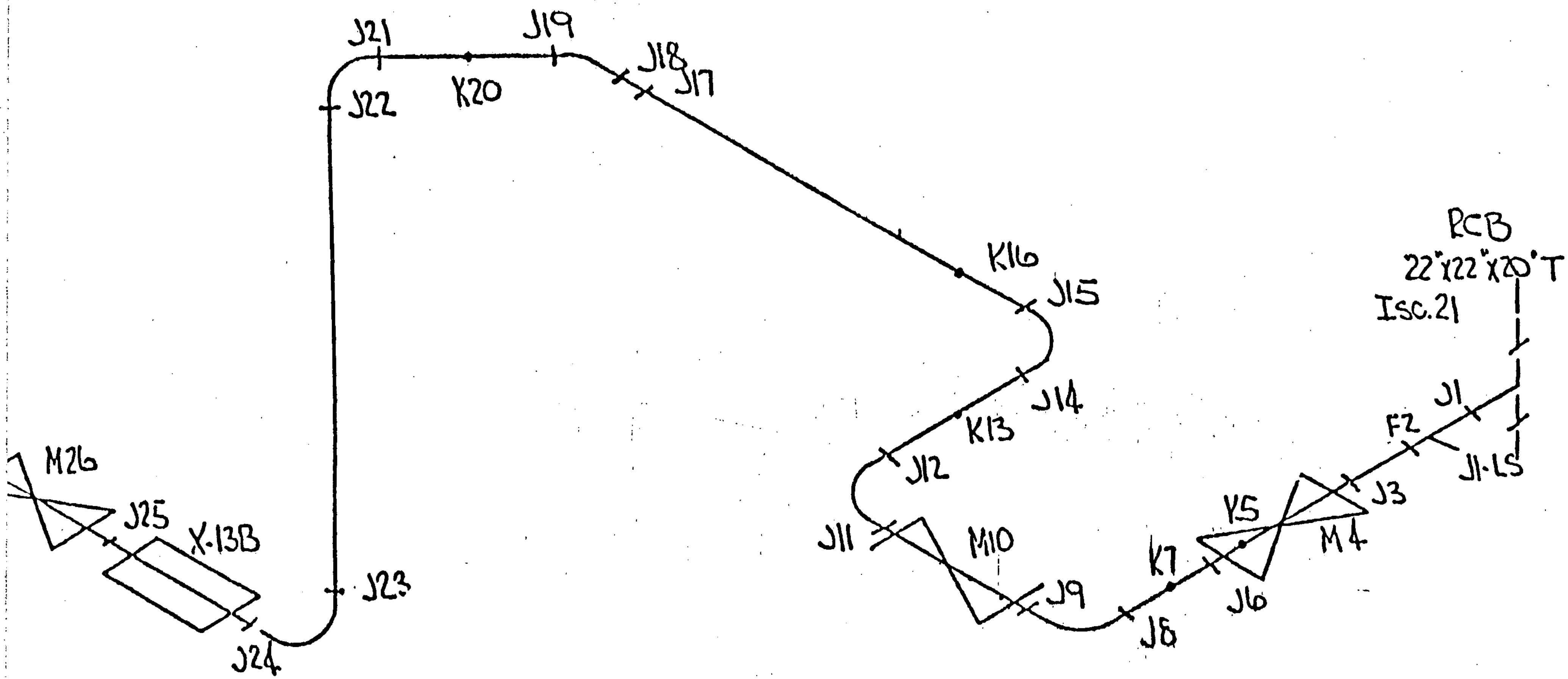
RESIDUAL HEAT REMOVAL - 20A

RHC -

SS, CS, 20"

ISO. NO. 15





RESIDUAL HEAT REMOVAL - 20B
RHD-
SS, CS, 20"
ISO. No. 16

IOW-20-004

Attachment 3

STRESS CORROSION CRACKING EVALUATION PROGRAM

DUANE ARNOLD ENERGY CENTER

Prepared for:
Iowa Electric Light & Power Company

Prepared by:
NUTECH
San Jose, California

Prepared by:

J. B. Martin, P.E.

M. D. Sullivan

Reviewed and Approved by:

P. C. Riccardella, P.E.

Issued by:

J. W. Axline, P.E.

Date: April 23, 1980

nutech

IOW-20-004

STRESS CORROSION CRACKING EVALUATION PROGRAM

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J. W. Axline, P.E.

Date: April 23, 1980

nutech

ABSTRACT

An intergranular stress corrosion cracking (IGSCC) survey of the austenitic stainless steel piping in the recirculation system and RHR system of the Duane Arnold Energy Center has been completed. The primary objective of the survey was to assist Iowa Electric Light & Power in its inservice inspection program by identifying the weld joints which are most susceptible to IGSCC. In the survey, material properties and fabrication data from the plant records were compiled for each joint. The Stress Rule Index (SRI), a method of evaluating the sustained stress level at the inside surface weld HAZ, was calculated for each joint. The materials data and SRI were then used to rank each weld joint according to its relative susceptibility to IGSCC. An IGSCC Susceptibility Matrix was developed as a means of ranking the weld joints. Through this matrix each weld joint is categorized into one of three regions. Region I represents combinations of SRI and material chemistry which have thus far proven to be immune to IGSCC. Regions II and III represent combinations more susceptible to IGSCC.

In addition to the ranking, all weld joints were categorized as conforming, nonconforming, or service-sensitive according to the guidelines given in NUREG-0313, Revision 0, the Nuclear Regulatory Commission document related to IGSCC of BWR piping.

The following summary highlights the results of the survey.

1. Of a total of 117 welds ≥10 inches in diameter, 19 welds were found to meet the requirements for conforming material as defined in NUREG-0313. Of the remaining 98 nonconforming welds, 4 were identified as having a high resistance to IGSCC because the base materials contained a carbon content between 0.035%

and 0.050% or because they are believed to have been fabricated using an inside surface water spray cooling technique.

2. None of the large diameter pipes (≥10 inches diameter) were in service-sensitive lines.

3. All of the 26, 4 inch diameter welds were found to contain base material defined as nonconforming by NUREG-0313, and 18 of these were located in service-sensitive lines. Two of these 18 welds have high resistance to IGSCC because the carbon content of base material was between 0.035% and 0.050%.

4. Forty-seven weld joints (33% of the total welds) were categorized in Region I of the IGSCC Susceptibility Matrix, representing the least susceptible welds. The remainder of the weld joints were evenly divided between Regions II and III.

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1.0 INTRODUCTION AND PROGRAM OBJECTIVE

As a result of the stress corrosion cracking incidents in welded austenitic stainless steel primary coolant piping in Boiling Water Reactors (BWRs) in recent years, Iowa Electric Light and Power instituted a program with NUTECH to evaluate the stress corrosion cracking propensity of stainless steel welds in the recirculation and residual heat removal (RHR) systems at the Duane Arnold Energy Center (DAEC). The objective of the program is to perform a review of plant fabrication records, a metallurgical review of these records to evaluate factors important to intergranular stress corrosion cracking (IGSCC) in the BWR environment, and a Stress Rule evaluation to assist in identifying those joints which are potentially susceptible to IGSCC. The ultimate program aim is to provide input to the DAEC Inservice Inspection Program so that the proper attention can be focused on those joints which are most susceptible to IGSCC. The identification of potentially susceptible pipe locations will also enable Iowa Electric to prepare for potential incidents by providing a repair or replacement plan to address the problem where it may exist. Additionally, this program will assist in addressing, in a more meaningful way, the concerns of the Nuclear Regulatory Commission published in NUREG-0313 and NUREG-0531 regarding materials selection and processing guidelines for BWRs.

The program is divided into the following four major tasks:

- Task 1. Review of Plant Records
- Task 2. Review of Metallurgical Variables
- Task 3. Stress Rule Evaluation
- Task 4. Identification of Low Failure Probability Joints

The following sections provide a brief description of the work performed under each of the above mentioned tasks.

2.0 REVIEW OF PLANT RECORDS

The objective of this task activity was to obtain and review all plant records required to complete the detailed evaluations described in Tasks 2 and 3. These records included piping fabrication and isometric drawings, stress reports, material certifications, fabrication procedures, and records regarding repairs and replacements.

An extremely complete and well-compiled set of fabrication records for the entire recirculation system were supplied to NUTECH by Mr. K. V. Harrington of Iowa Electric, greatly facilitating this task activity.

3.0 REVIEW OF METALLURGICAL VARIABLES

The objective of this task was to identify, for each stainless steel joint in the recirculation and RHR systems, the material chemistry, significant fabrication practices that may have an effect on the joint's susceptibility to IGSCC, and determine the NUREG-0313 status. A detailed compilation of this information is presented in the Stress Corrosion Cracking Evaluation Tables included as Appendix A to this report.

3.1 Material Chemistry

Certified material test reports were located for each component of the subject piping systems. The material specification and the associated carbon content are identified in SCC Evaluation Tables, Appendix A.

Unstabilized wrought austenitic stainless steel with a carbon content less than 0.035% has been demonstrated to be highly resistant to stress corrosion cracking and is acceptable to the NRC for installation in BWR piping systems, as stated in NUREG-0313. Welds between materials with a carbon content in the 0.035% to 0.050% range are identified in the SCC Evaluation Tables as having high resistance to IGSCC. While no NRC credit can be taken for these welds relative to NUREG-0313 guidelines, we feel it is appropriate, based on field failure data and the EPRI sponsored pipe test and laboratory test data, to identify these joints as highly resistant to IGSCC. The General Electric test data presented in Figure 3-1 illustrates that at these carbon levels Type 304 stainless steel is highly resistant to IGSCC.

Ferritic steels and cast stainless steels have also been demonstrated to be highly resistant to IGSCC and are acceptable materials for installation in BWR piping systems. Inconel (Alloy 600), not addressed specifically in NUREG-0313, is considered as a conforming material in this evaluation. In the uncreviced condition this material has provided satisfactory performance in the BWR environment.

3.2 Significant Fabrication Practices

A review of the fabrication procedures revealed that the large diameter shop welds may have been fabricated using an inside surface water spray cooling technique. The pipe fabricator, Southwest Fabricating and Welding Co., commonly uses the spray cool technique to maintain interpass temperature when welding stainless steel pipe having a wall thickness greater than 0.75 in.[(1)] The main purpose for employing this technique was to control interpass temperature, however, the technique is similar to that currently being studied as a fabrication remedy for stress corrosion cracking mitigation.

This technique, also called heat sink welding (HSW), is used to produce axial compressive residual stress on the inside pipe surface in the weld heat affected zone. The first two layers are deposited by the gas tungsten arc process in the normal manner. The remainder of the weld is made while the inside surface is being cooled by either a water spray or by filling the pipe with flowing water.

It has been documented in General Electric Company's pipe tests on small diameter piping that as much as an order of magnitude performance improvement may be possible for heat sink welded joints.[(2)] A separate program, supported by the Electric Power

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(1) Robert Pearson, Southwest Fabricating and Welding Co., Private Communication

(2) R. Hughes, Qualification of Solution Heat Treatment, Corrosion Resistant Cladding and Heat Sink Welding. Seminar on Countermeasures for BWR Pipe Cracking, January 22-24, 1980.

Research Institute, is currently underway to evaluate the residual stress benefit for large diameter piping fabricated using this process.

Although no NRC credit can currently be taken for heat sink welded joints in relation to the augmented ISI requirements of NUREG-0313, these welds are specifically highlighted in the SCC Evaluation Tables because of their potentially high resistance to IGSCC. It should also be noted that, although the shop welding procedure used in fabricating the Duane Arnold spools requires interpass temperature control, and allows water spray cooling, specific documentation describing the detailed process and verifying its use on each of the shop welds has not been located. Follow-up discussions with the pipe fabricator will be necessary to provide adequate assurance that the water spray cooling technique was, in fact, employed for each shop weld.

3.3 NUREG-0313 Evaluation

An evaluation of the metallurgical data compiled for each joint was conducted with respect to the NRC technical positions established in NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," published in July 1977.

The SCC Evaluation Tables identify the NUREG-0313 status of each joint based on the following criteria.

Conforming - joints for which each of the adjoining parent materials are one of the following highly resistant materials; ferritic steels, "Nuclear Grade" or L-Grade Type 304 or 316 austenitic stainless steel (<0.035% Carbon), or cast stainless steels. Regular grades of 304 or 316 stainless steel are not considered conforming unless the as-installed piping, including the weld, is in the solution annealed condition.

Nonconforming - all joints not meeting the above criteria. These joints are subject to augmented inservice inspection requirements as identified in NUREG-0313.

Service Sensitive - nonconforming joints in lines designated by the NRC as having experienced cracking of a generic nature, or that are considered to be particularly susceptible to cracking because of a combination of high local stress material condition, and high oxygen content in lines which have relatively stagnant, intermittent, or low flow coolant. Included in this category of piping runs are: core spray lines, recirculation bypass lines, CRD hydraulic return lines, isolation condenser lines, and shutdown heat exchanger lines. A higher degree of augmented inspection is required for these lines.

A revision of NUREG-0313, currently issued for review and comment, proposes to add recirculation riser piping and internal attachment welds to the service sensitive category.

3.4 Summary

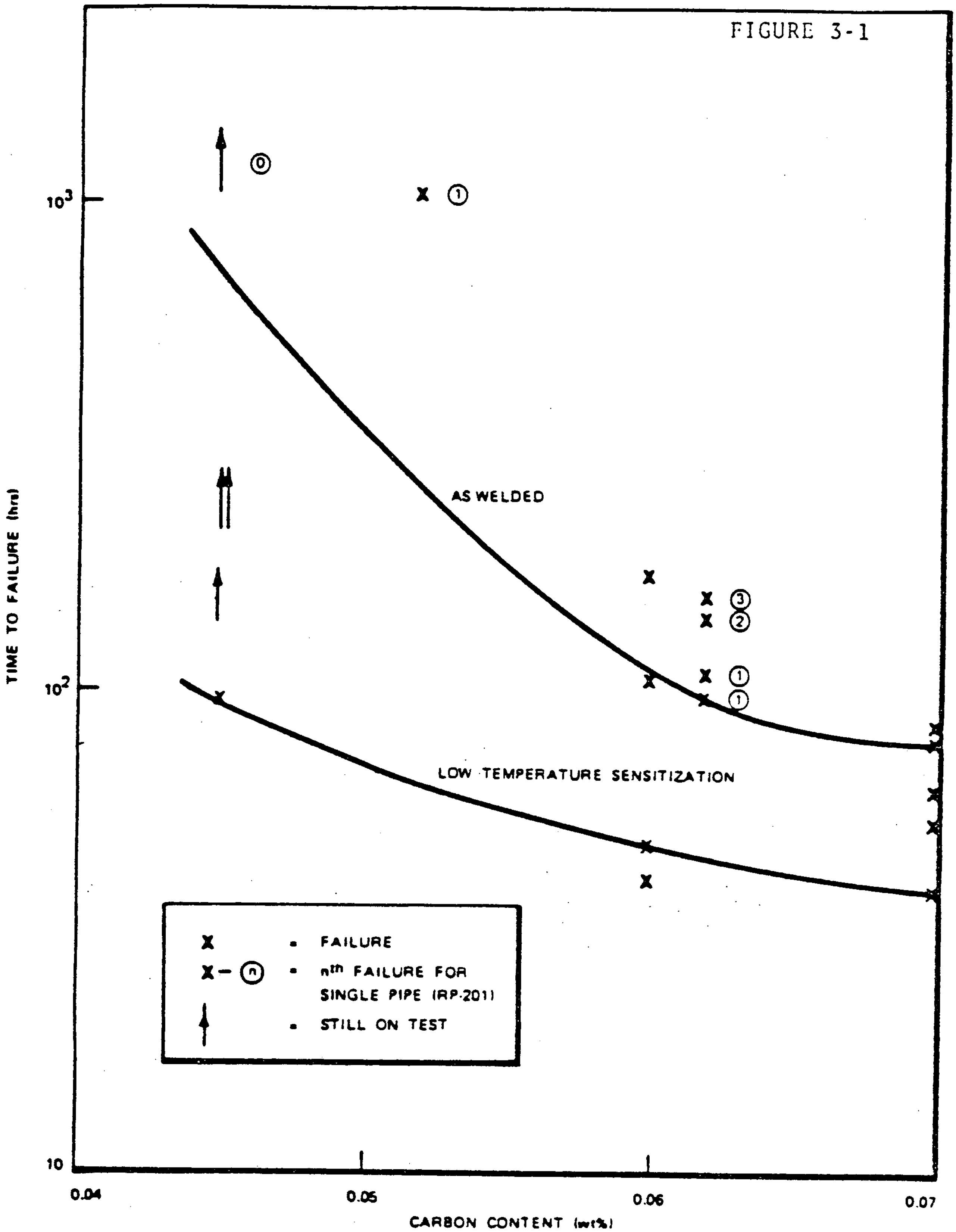
The overall metallurgical review consisted of an examination of 136 joints in the recirculation system and 7 joints in the residual heat removal system. Of the 143 total joints, 19 were evaluated as conforming, 106 were nonconforming, and 18 were both nonconforming and in service sensitive lines.

Of a total of 117 welds greater than or equal to 10 inches in diameter, 19 welds were found to meet the requirements for conforming material as defined in NUREG-0313. Of the remaining 98 nonconforming welds, 34 were identified as having a high resistance to IGSCC because the base materials contained a carbon content between 0.035% and 0.050% or because they are believed to have been fabricated using an inside surface water cooling technique.

All of the 26, 4-inch diameter welds were found to contain base material defined as nonconforming by NUREG-0313, and 18 of these were located in service sensitive lines. Two of these 18 welds were designated as having a high resistance to IGSCC because the carbon content of the base material was between 0.035% and 0.050%.

Table 3-2 provides a tabular summary of the metallurgical evaluation results.

FIGURE 3-1



CARBON CONTENT VERSUS TIME TO FAILURE IN TYPE-304 STAINLESS STEEL PIPE TESTS
(REF: NEDC 23750-2, EPRI CONTRACT RP968)

nutech

TABLE 3-2

SUMMARY OF METALLURGICAL EVALUATION RESULTS

SYSTEM	DIA	TOTAL WELDS	TOTAL CONFORMING WELDS	NON-CONF. WELDS SHOP WATER SPRAY COOLED*	NON-CONF. WELDS WITH .035 <%C <.050	TOTAL NON-CONFORMING WELDS	TOTAL NON-CONFORMING & SERVICE SENSITIVE
RECIRCULATION SUCTION	22	23	2	10	15	21	0
RECIRCULATION DISCHARGE	22	16	0	6	1	16	0
RECIRCULATION RING HEADER	16	8	0	8	0	8	0
RECIRCULATION RISERS	10	64	16	0	0	48	0
RECIRCULATION BYPASS	4	18	0	0	2	0	18
RECIRCULATION BRANCH CONNECTIONS	4	7	0	0	0	7	0
RESIDUAL HEAT REMOVAL	20	4	0	0	0	4	0
	18	2	1	0	0	1	0
	4	1	0	0	0	1	0
TOTAL		143	19	24**	18**	106	18

*The use of water spray cooling not yet fully verified.

**Each column includes six joints that satisfy both criteria (i.e., .035 < %C < .050 and shop water spray cooled.)

4.0 STRESS RULE EVALUATION

To provide a further means of determining a joint's susceptability to IGSCC, a Stress Rule Index (SRI) evaluation was performed for each joint being studied. The Stress Rule Index is determined in the following manner. The axial stress components resulting from sustained loading conditions (i.e. pressure, deadweight, and steady state thermal expansion) are derived from the elemental force and moment tables of the original Duane Arnold piping stress analysis. These are combined with residual stress estimates and input to the General Electric Company developed Stress Rule Index equation shown below.

$$\frac{P_m + P_b}{S_y} + \frac{Q + F\ (Resid)}{S_y + .002E} = SRI$$

Where

P_m	=	Primary Membrane Stress
P_b	=	Primary Bending Stress
S_y	=	Code Yield Strength
Q	=	Sustained Secondary Stress
F	=	Sustained Peak Stress
E	=	Elastic Modulus
Resid	=	Weld Residual Stress

For non-creviced welds, General Electric Company has determined that if the index is less than unity, susceptibility to stress corrosion cracking is mitigated; for crevices, a value somewhat lower than unity may be more suitable. To this date, IGSCC events have not been observed in joints exhibiting a SRI less than 1.2.

The SRI evaluation was facilitated by the use of a NUTECH computer program (SCORE) which calculates the SRI given the appropriate forces and moments from the piping stress report. The SRI for each joint is given in the SCC Evaluation Tables. Detailed results of the SRI evaluation are included in Appendix B.

5.0 IDENTIFICATION OF LOW FAILURE PROBABILITY JOINTS

Three main considerations must be taken into account in determining the susceptibility of a joint to intergranular stress corrosion; material properties, stress, and environment. In this report, we have quantitatively addressed two of these three factors. For both material properties and stress, there exists sufficient analysis, laboratory data, and field experience to provide a basis for determining relative susceptibility. The environmental factor has only been addressed in that stagnant, low flow lines (service sensitive) are considered more susceptible to IGSCC. The degree to which one of these three ingredients must be present for IGSCC to occur is variable, making it extremely difficult to combine what is known about each of these factors to define an absolute scale of susceptibility. There are also other known variables that effect the susceptibility of sensitized austentic stainless steel to IGSCC. These other variables, which must be factored into a final determination of susceptibility, include such effects as cold work, counterbore grinding crevices, temperature, pH, etc. EPRI is currently sponsoring research that may lead to more refined techniques for quantifying the susceptibility of various piping joints.

To provide a rudimentary means of ranking each weld, the IGSCC Susceptibility Matrix was developed. It displays the relative susceptibility of each weld based on the information that has been compiled in this study regarding material properties and stress conditions. Figure 5-1 shows the placement of the recirculation and RHR system welds in the matrix based on the stress rule index calculated for that joint and the highest carbon content of the base material on either side of the weld.

The IGSCC Susceptibility Matrix is divided into three regions labeled I, II, and III. Region I contains welds that are either conforming from a material standpoint (less than 0.035% carbon as defined in NUREG-0313) or have a stress rule index less than 1.2. (IGSCC events have not been observed in weld joints with a SRI < 1.2.) Welds in this region are considered to be the least susceptible to IGSCC.

Region II defines an intermediate zone encompassing welds which exhibit considerable margin to failure, relative to Region III welds, but are somewhat more susceptible than Region I welds. Finally, Region III represents the most susceptible welds, those having the smallest margin to failure.

Other variables, as discussed earlier, can enter in to increase or decrease the susceptibility to IGSCC. Two of the more important factors to be considered for Duane Arnold are the effects of shop water spray cooling and whether specific welds are in service sensitive piping. Welds that are believed to have been shop water spray cooled are underlined in the matrix. These welds are potentially highly resistant to IGSCC because of favorable residual stress distribution. If this is verified and actual measurements determine the extent to which these stresses are reduced, the stress rule index may be significantly lowered, thus shifting the position of the underlined welds to the left. The other important factor to consider is whether welds are in service sensitive piping. Welds which are both nonconfoming and in service sensitive piping are identified in the matrix with an asterisk. These welds are potentially more susceptible to IGSCC than other welds of the same matrix position.

STRESS RULE INDEX

CARBON CONTENT (%)	0 - 1.20	1.21 - 1.50	1.51 - 2.00	2.01 →
.070 →	RRA-J7 RRD-J7 RRE-J7 RRF-J7 RRH-J7	RCA-J18 RMA-J10 RRG-J7 RCB-J21 RRB-J7 RRC-J7	RMA-J4 RMA-J2 RMB-J11 RMB-J2	RMA-J8 RMB-J5 RMB-J9
.060 - .069	RCA-J27 RBA-J7* RCB-J30 RHC-F2 RHD-F2	RCA-J34 RBA-J1* RRE-J4 RRF-J4 RRC-J4 RRD-J4 RCB-J37 RBB-J1* RBB-J7* RBB-J12* RHC-J1 RHD-J1	RRA/H-J5 (8 welds) RBA-J6* RBA-J8* RRG-J4 RRH-J4 RRA-J4 RRB-J4 RBB-J6* RBB-J8* REGION III (HIGH SUSCEPTIBILITY)	
.050 - .059	RCA-J7 RCA-J15 RCA-J24 RCA-J28 RCA-J38 RMA-J1 RMA-J11 RRA/H-J4A (8 welds) RCB-J27 RCB-J31 RCB-J41 RMB-J1 RMB-J12 RHB-J1	RCA-J12 RCA-J13 RCA-J21 RCA-J30 RCA-J32 RCA-J41 RCA-J43 RMA-J6 RRA/H-J3 (8 welds) RMA-J5 RMA-J7 RBA-J2* RBA-J3* RCB-J6 RCB-J7 RCB-J33 RCB-J35 RCB-J24 RMB-J7 RMB-J6 RMB-J8 RBB-J2* RBB-J3*	RBA-J9* RBB-J9*	
.035 - .049	RCA-J3 RCA-J6 RCB-J3 RCB-J9 RCB-J18	RCA-J4 RCA-J5 RBA-J12* RCB-J4 RCB-J5 RCB-J15 RCB-J16 RCB-J24 RCB-J46 REGION II (MODERATE SUSCEPTIBILITY)	RCA-J22 RBA-J10* RCB-J25 RBB-J10*	
<.035	RHB-F3 RCA-F2 RCB-F2 RRA/H-F2A (8 welds)	REGION I (LOW SUSCEPTIBILITY)		

* IN SERVICE SENSITIVE LINES
xxx SHOP WATER SPRAY COOLED

FIGURE 5-1

IGSCC SUSCEPTIBILITY MATRIX

APPENDIX A

SCC EVALUATION TABLES

Prepared for IOWA ELECTRIC LIGHT & POWER COMPANY

STRESS CORROSION CRACKING EVALUATION

DUANE ARNOLD ENERGY CENTER

Prepared by **nutech**

LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCA	RECIRCULATION SUCTION - LOOP A	0 4/11/80	A1

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	SENS	NONCONF	CONF	STRESS RULE INDEX	COMMENTS
				RECIRC. SUCTION NOZZLE (N1A)	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						
RCA-F2	22	NOZ-SE	SW									X	1.01	
				SAFE-END (N1A)	FORGED SA-336 GR F8	7	M57S	0.023						
RCA-J3	22	SE-P	FW								θ+		1.03	LOWER %C HIGH RESISTANCE TO IGSCC
				PIPE (5-1)	R&W A358 CL.1 FROM A240 T304	1	2P2470-4A	0.045						
RCA-J4	22	P-E	SW								θ+		1.30	LOWER %C & SHOP WATER SPRAY COOLED HIGH RESISTANCE TO IGSCC
				ELBOW(90°LR)	R&W A403-WP304W FROM A240	2	300223	0.049						
RCA-J5	22	E-P	SW								θ+		1.32	LOWER %C & SHOP WATER SPRAY COOLED HIGH RESISTANCE TO IGSCC
				PIPE (5-2)	R&W A358 CL.1 FROM A240 T304	1	2P2470-4A	0.045						
RCA-J6	22	P-P	FW								θ+		0.90	LOWER %C HIGH RESISTANCE TO IGSCC
				PIPE (6-1)	R&W A358 CL.1 FROM A240 T304	1	2P2470-1A	0.045						
RCA-J7	22	P-P	SW								θ+		0.87	SHOP WATER SPRAY COOLED
				PIPE (6-2)	R&W A358 CL.1 FROM A240 T304	1	300069-1B	0.050						
RCA-J12	22	P-E	SW								θ+		1.30	SHOP WATER SPRAY COOLED
				ELBOW(90°LR)	R&W A403-WP304W FROM A240	2	300223	0.049						
RCA-J13	22	E-V	FW								θ+		1.33	LOWER %C TO CASTING HIGH RESISTANCE TO IGSCC
				VALVE (MO-F023A)	CAST A351-65 GR CF-8	7	40298	0.05						9% FERRITE

Prepared for
IOWA ELECTRIC LIGHT & POWER COMPANY

STRESS CORROSION CRACKING EVALUATION

DUANE ARNOLD ENERGY CENTER

Prepared by **nutech**

LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCA	RECIRCULATION SUCTION - LOOP A (CON'T)	0 4/11/80	A2

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NONCONF	CONF	STRESS RULE INDEX	COMMENTS
RCA-J15	22	V-P	FW								X		0.96	
				PIPE (4-1)	R&W A358 CL.1 FROM A240 T304	1	300069-1B	0.050						
RCA-J21	22	P-E	SW								X→		1.43	SHOP WATER SPRAY COOLED
				ELBOW(90°SR)	R&W A403-WP304W-1967 FROM A240	3	K51142-3	0.048						
RCA-J22	22	E-Pp	FW								X→		1.63	LOWER %C TO CASTING HIGH RESISTANCE TO IGSCC
				PUMP	CAST A351 GR. CF8M	7	51510 or 50448	0.06 0.05						14% FERRITE
				PIPE (5-2)	R&W A358 CL.1 FROM A240 T304	1	2P2470-4A	0.045						SPOOL 5-2 ALSO SHOWN ON PG. A1
RCA-J5A	4	BPC	SW								X			
				WELDOLET 22" X 4"	FORGED A182-F304	6	812680 (496E)	0.060						
				PIPE (4-1)	R&W A358 CL.1 FROM A240 T304	1	300069-1B	0.050						SPOOL ALSO SHOWN ON PG. A2
RCA-J18	4	BPC	SW								X		1.32	
				4" WN FLANGE (900# LONG)	FORGED A182-69 F-304	4	41167	0.070						DECONTAMINATION FLANGE
				BLIND FLANGE	FORGED A182-69 F-304	4	41167	0.070						

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STRESS CORROSION CRACKING EVALUATION

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCA	RECIRCULATION DISCHARGE - LOOP A	0 4/11/80	A3

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV SENS	NUREG 0313 STATUS: NON CONF	NUREG 0313 STATUS: CONF	STRESS RULE INDEX	COMMENTS
				PUMP	CAST A351 CF8M	7	51510 or 50448	0.06 0.05					14% FERRITE
RCA-J24	22	Pp-P	FW							X		0.98	
			-	PIPE (7-1)	R&W A358 CL.1 FROM A240 T304	1	300075-1B	0.058					
RCA-J28	22	P-V	FW							X		0.97	
				VALVE (MO-F031A)	CAST A351-65 GR. CF8	7	44266	0.04					18% FERRITE
RCA-J30	22	V-E	FW							X		1.27	
				ELBOW(90°LR)	R&W A403-WP304W FROM A240	2	600324-1A	0.055					
RCA-J32	22	E-P	SW							⊖+		1.26	SHOP WATER SPRAY COOLED
				PIPE (9-1)	R&W A358 CL.1 FROM A240 T304	1	300075-1B	0.058					
RCA-J38	22	P-P	SW							X		0.89	
				PIPE (9-1)	R&W A358 CL.1 FROM A240 T304	1	300075-IB	0.058					FLOW RESTRICTER WELDED TO PIPE I.D.
RCA-J41	22	P-T	SW							⊖+		1.25	SHOP WATER SPRAY COOLED
				REDUCING TEE 22"X22"X20"	R&W A403-WP304W FROM A240	2	6003241	0.055					20" OUTLET EXTRUDED PRIOR TO HEAT TREATMENT
RCA-J43	22	T-Cr	FW							X		1.33	
				REDUCING CROSS 22X22X16X16	R&W A403-WP304W FROM A240-69	2	582533-1	0.040					16" OUTLETS EXTRUDED PRIOR TO HEAT TREATMENT
RMA-J6	22	Cr-Cp	SW							⊖+		1.22	SHOP WATER SPRAY COOLED
				WELD CAP	R&W A403-WP-304-67 FROM A240	3	600225-1A	0.058					

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STRESS CORROSION CRACKING EVALUATION

DUANE ARNOLD ENERGY CENTER

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RMA	RECIRCULATION RING HEADER - LOOP A	0 4/11/80	A5

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				WELD CAP	R&W A403-WP304-67 FROM A240	3	K51404-4D	).050						
RMA-J1	16	C -Hdr	SW										0.96	SHOP WATER SPRAY COOLED
				RING HEADER 24-1	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	.059						RISER OUTLETS EXTRUDED PRIOR TO HEAT TREATMENT
RMA-J5	16	Hdr-Cr	SW										1.42	SHOP WATER SPRAY COOLED
				REDUCING CROSS 22X22X16X16	R&W A403 WP-304W FROM A240-69	2	582533-1	.040						ALSO SHOWN ON PG. A3
RMA-J7	16	Cr-Hdr	SW										1.37	SHOP WATER SPRAY COOLED
				RING HEADER	R&W A358 CL.1 FROM	1	600120-1B	.059						RISER OUTLETS EXTRUDED PRIOR TO HEAT TREATMENT
RMA-J11	16	Hdr-Cp	SW										0.96	SHOP WATER SPRAY COOLED
				WELD CAP	R&W A403-WP304-67 FROM A240	3	K51404-4D	.050						

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STRESS CORROSION CRACKING EVALUATION

DUANE ARNOLD ENERGY CENTER

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRE	RECIRCULATION RISERS - LOOP A (N2E)	0 4/11/80	A6

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (24-2)	R&W A358 CL.1 FROM A240 T304	1	600120-1B	0.059						ALSO SHOWN ON PG. A5
RMA-J10	10	Hdr-A	SW								X		1.40	
				ADAPTER	FORGED A182-F304	6	52624	0.070						
RRE-J7	10	A-P	FW								X		1.11	
				PIPE (12-2)	SMLS A376-TP304	5	2P3687	0.051						
RRE-J5	10	P-E	SW								X		1.56	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061						
RRE-J4	10	E-P	SW								X		1.39	
				PIPE (12-1)	SMLS A376-TP304	5	2P3399	0.055						
RRE-J4A	10	P-P	FW								X		0.98	
				PIPE (12-1)	SMLS A376-TP304	5	2P3399	0.055						PORTION OF SPOOL 12-1 WAS CUT OUT AND REWELDED IN 1978
RRE-J3	10	P-P	FW								X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030						
RRE-F2A	10	P-SE	FW									X	1.02	
				SAFE-END (N2E)	SMLS SB-166 INCONEL	7	NX8927	0.07						SAFE-END REPLACED IN 1978
RRE-F2	10	SE-NOZ	FW									X	1.03	
				RECIRC INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRF	RECIRCULATION RISERS - LOOP A (N2F)	0 4/11/80	A7

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV SENS	NUREG 0313 STATUS: NON CONF	NUREG 0313 STATUS: CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (24-2)	R&W A358 CL.1 FROM A240 T304	1	600120-IB	0.059					ALSO SHOWN ON PG. A5
RMA-J8	10	Hdr-A	SW							X		2.05	
				ADAPTER	FORGED A182-F304	6	52624	0.070					
RRF-J7	10	A-P	FW							X		1.20	
				PIPE (13-2)	SMLS A376-TP304	5	2P3271	0.061					
RRF-J5	10	P-E	SW							X		1.70	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061					
RRF-J4	10	E-P	SW							X		1.41	
				PIPE (13-1)	SMLS A376 TP304	5	2P3687	0.051					
RRF-J4A	10	P-P	FW							X		0.98	
				PIPE (13-1)	SMLS A376 TP304	5	2P3687	0.051					PORTION OF SPOOL 13-1 WAS CUT OUT AND REWELDED IN 1978
RRF-J3	10	P-P	FW							X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030					
RRF-F2A	10	P-SE	FW								X	1.02	
				SAFE-END (N2F)	SMLS SB-166 INCONEL	7	NX8927	0.07					SAFE-END REPLACED IN 1978
RRF-F2	10	SE-NOZ	FW								X	1.03	
				RECIRC INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---					

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRG	RECIRCULATION RISERS - LOOP A (N2G)	0 4/11/80	A8

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NDN	CDNF	CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (24-1)	R&W A358 CL.2 FROM A240 T304	1	600120-1B	0.059							ALSO SHOWN ON A5
RMA-J4	10	Hdr-A	SW									X		1.51	
				ADAPTER	FORGED A182-F304	6	52624	0.070							
RRG-J7	10	A-P	FW								X			1.22	
				PIPE (14-2)	SMLS A376-TP304	5	2P3271	0.061							
RRG-J5	10	P-E	SW									X		1.68	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061							
RRG-J4	10	E-P	SW									X		1.53	
				PIPE (14-1)	SMLS A376-TP304	5	2P3687	0.051							
RRG-J4A	10	P-P	FW								X			0.98	
				PIPE (14-1)	SMLS A376-TP304	5	2P3687	0.051							PORTION OF SPOOL 14-I WAS CUT OUT AND REWELDED IN 1978
RRG-J3	10	P-P	FW								X			1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030							
RRG-F2A	10	P-SE	FW										X	1.02	
				SAFE-END (N2G)	SMLS SB-166 INCONEL	7	NX9923	0.06							SAFE-END REPLACED IN 1978
RRG-F2	10	SE-NOZ	FW										X	1.03	
				RECIRC INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	----							

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRH	RECIRCULATION RISERS - LOOP A (N2H)	0 4/11/80	A9

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (24-1)	R&W A358 CL.1 FROM A240 T304	1	600120-1B	0.059						ALSO SHOWN ON PG. A5
RRH-J2	10	Hdr-A	SW								X		1.90	
				ADAPTER	FORGED A182-F304	6	52624	0.070						
RRH-J7	10	A-P	FW								X		1.14	
				PIPE (15-2)	SMLS A376-TP304	5	2P3687	0.051						
RRH-J5	10	P-E	SW								X		1.55	
				ELBOW	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061						
RRH-J4	10	E-P	SW								X		1.57	
				PIPE (15-1)	SMLS A376-TP304	5	2P3687	0.051						
RRH-J4A	10	P-P	FW								X		0.98	
				PIPE (15-1)	SMLS A376-TP304	5	2P3687	0.051						PORTION OF SPOOL 15-1 WAS CUTOUT AND REWELDED IN 1978
RRH-J3	10	P-P	FW								X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030						
RRH-F2A	10	P-SE	FW									X	1.02	
				SAFE-END (N2H)	SMLS SB-166 INCONEL	7	NX9923	0.06						SAFE-END REPLACED IN 1978
RRH-F2	10	SE-NOZ	FW									X	1.03	
				RECIRC INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RBA	RECIRCULATION BYPASS LINE - LOOP A	0 4/11/80	A10

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	NUREG 0313 STATUS: SENS	NUREG 0313 STATUS: NON CONF	NUREG 0313 STATUS: CONF	STRESS RULE INDEX	COMMENTS
				WELDOLET	FORGED A182-F304	6	812680 (496E)	0.060						ALSO SHOWN ON PG. A4
RBA-J1	4	WOL-P	FW						X		X		1.22	
				PIPE	SMLS A376-TP304	5	2P3535	0.053						
RBA-J2	4	P-E	SW						X		X		1.40	
				ELBOW(90°LR)	SMLS A403-WP304-67 FROM A376	3	20257 CFRO	0.047						
RBA-J3	4	E-P	SW						X		X		1.50	
				PIPE	SMLS A376-TP304	5	2P3371	0.057						
RBA-J6	4	P-T	FW						X		X		1.83	
				TEE	SMLS A403-WP304W-67 FROM A312	3	37368 CFRP	0.060						
RBA-J7	4	T-FL	SW						X		X		1.16	
				WN FLANGE (900 #LONG)	FORGED A182-F316	4	E1460	0.060						
				BLIND FLANGE	FORGED A182-F316	4	E1460	0.060						
				TEE	SMLS A403-WP304W-67 FROM A312	3	37368 CFRP	0.060						ALSO SHOWN ON PG. A4
RBA-J8	4	T-P	FW						X		X		1.94	
				PIPE	SMLS A376-TP304	5	2P3371	0.057						
RBA-J9	4	P-E	SW						X		X		1.72	

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RBA	RECIRCULATION BYPASS LINE - LOOP A (CON'T)	0 4/11/80	A11

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON	C ONF	CONF	STRESS RULE INDEX	COMMENTS
				ELBOW(90°LR)	SMLS A403-WP304W-67 FROM A312	3	20257 CFRO	0.047							
RBA-J10	4	E-V	FW						θ→		X			1.52	LOWER %C TO CASTING HIGH RESISTANCE TO IGSCC
				VALVE (MO-F032A)	CAST A351-65 GR. CF8	7	41706	0.08							8% FERRITE
RBA-J12	4	V-WOL	FW						X		X			1.31	
				WELDOLET	FORGED A182-F304	6	812680 (876E)	0.060							ALSO SHOWN ON PG. A4

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCB	RECIRCULATION SUCTION - LOOP B	0 4/11/80	A12

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NONCONF	CONF	STRESS RULE INDEX	COMMENTS
				RECIRC. SUCTION NOZZLE (N1B)	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						
RCB-F2	22	NOZ-SE	SW									X	0.97	
				SAFE-END (N1B)	FORGED SA-336 GR. F8	7	M57S	0.023						
RCB-J3	22	SE-P	FW								0→		1.01	LOWER %C HIGH RESISTANCE TO IGSCC
				PIPE (1-1)	R&W A358 CL.1 FROM A240 T304	1	2P2470-4A	0.045						
RCB-J4	22	P-E	SW								0→		1.35	LOWER %C & SHOP WATER SPRAY COOLED HIGH RESISTANCE TO IGSCC
				ELBOW(90°LR)	R&W A403-WP304W FROM A240	2	300223	0.049						
RCB-J5	22	E-P	SW								0→		1.24	LOWER %C & SHOP WATER SPRAY COOLED HIGH RESISTANCE TO IGSCC
				PIPE (1-2)	R&W A358 CL.1 FROM A240 T304	1	2P2470-1A	0.045						
RCB-J6	22	P-T	FW								X		1.24	
				REDUCING TEE 22"X22"X18"	R&W A403-WP304W FROM A240-69	2	6003241	0.055						18" OUTLET EXTRUDED PRIOR TO HEAT TREATMENT
RCB-J7	22	T-P	SW								0→		1.32	SHOP WATER SPRAY COOLED
				PIPE (1-2)	R&W A358 CL.1 FROM A240 T304	1	2P2470-1A	0.045						
RCB-J9	22	P-P	SW								0→		0.89	LOWER %C & SHOP WATER SPRAY COOLED HIGH RESISTANCE TO IGSCC
				PIPE (2-1)	R&W A358 CL. 1 FROM A240 T304	1	2P2431-1A	0.040						
RCB-J15	22	P-E	FW								0→		1.31	LOWER %C HIGH RESISTANCE TO IGSCC
				ELBOW(90°LR)	R&W A403-WP304W FROM A240	2	300223	0.049						
RCB-J16	22	E-V	FW								0→		1.32	LOWER %C HIGH RESISTANCE TO IGSCC

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCB	RECIRCULATION SUCTION - LOOP B (CON'T)	0 4/11/80	A13

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				VALVE (MO-F023B)	CAST A351-65 GR. CF8	7	39839	0.06						11% FERRITE
RCB-J18	22	V-P	FW								⊕→		0.96	LOWER %C TO CASTING HIGH RESISTANCE TO IGSCC
				PIPE (3-1)	R&W A358 CL.1 FROM A240 T304	1	2P2470-4A	0.045						
RCB-J24	22	P-E	SW								⊕→		1.38	LOWER %C & SHOP WATER SPRAY COOLED HIGH RESISTANCE TO IGSCC
				ELBOW(90°SR)	R&W A403-WP304W-67 FROM A240 T304	3	K51142-3	0.048						
RCB-J25	22	E-Pp	FW								⊕→		1.57	LOWER %C TO CASTING HIGH RESISTANCE TO IGSCC
				PUMP	CAST A351 GR. CF8M	7	51510 or 50448	0.06 0.05						14% FERRITE
				PIPE (3-1)	R&W A358 CL.1 FROM A240 T304	1	2P2470-4A	0.045						
RCB-J21	4	BPC	SW								X		1.32	
				FLANGE (900# LNW)	FORGED A182-69 F-304	4	41167	0.070						DECONTAMINATION FLANGE
				BLIND FLANGE	FORGED A182-69 F-304	4	41167	0.070						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCB	RECIRCULATION DISCHARGE - LOOP B	0 4/11/80	A14

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				PUMP	CAST A351 CF8M	7	51510 or 50448	0.06 0.05						14% FERRITE
RCB-J27	22	Pp-P	FW								X		0.97	
				PIPE(8-1)	R&W A358 CL.1 FROM A240 T304	1	300075-1C	0.058						
RCB-J31	22	P-V	FW								X		0.96	
				VALVE (MO-F031B)	CAST A351-65 GR. CF8	7	44691	0.04						15% FERRITE
RCB-J33	22	V-E	FW								X		1.24	
				ELBOW(90°LR)	R&W A403-WP304W FROM A240	2	600324-1A	0.055						
RCB-J35	22	E-P	SW								θ+		1.22	SHOP WATER SPRAY COOLED
				PIPE (10-1)	R&W A358 CL. 1 FROM A240 T304	1	300075-1C	0.058						
RCB-J41	22	P-P	SW								X		0.90	
				PIPE (10-1)	R&W A358 CL.1 FROM A240 T304	1	300075-1C	0.058						FLOW RESTRICTER WELDED TO PIPE I.D.
RCB-J44	22	P-T	SW								θ+		1.43	SHOP WATER SPRAY COOLED
				REDUCING TEE 22X22X20	R&W A403-WP304W FROM A240-69	2	6825331	0.040						20" OUTLET EXTRUDED PRIOR TO HEAT TREATMENT
RCB-J46	22	T-Cr	FW								θ+		1.33	LOWER %C CONTENT - HIGH RESISTANCE TO IGSCC
				REDUCING CROSS 22X22X16X16	R&W A403-WP304W FROM A240-69	2	6825331	0.040						16" OUTLETS EXTRUDED PRIOR TO HEAT TREATMENT
RMB-J7	22	Cr-Cp	SW								θ+		1.22	SHOP WATER SPRAY COOLED
				WELD CAP	R&W A403-67 FROM A240 T304	3	600225-1A	0.058						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RCB	RECIRCULATION DISCHARGE - LOOP B (CON'T)	0 4/11/80	A15

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				22" PIPE (8-1)	R&W A358 CL.1 FROM A240 T304	1	300075-1C	0.058						ALSO SHOWN ON PG. A14
RCB-J30	4	BPC	SW								X		1.08	
				WELDOLET 22"X4"	FORGED A182-F304	6	812680 (496E)	0.060						BRANCH CONNECTION FOR 4" RECIRC. DISCHARGE VALVE BYPASS LINE
				22" PIPE (10-1)	R&W A358 CL.2 FROM A240 T304	1	300075-1C	0.058						ALSO SHOWN ON PG. A14
RCB-J37	4	BPC	SW								X		1.25	
				WELDOLET 22"X4"	FORGED A182-F304	6	812680 (496E)	0.060						BRANCH CONNECTION FOR 4" RECIRC. DISCHARGE VALVE BYPASS LINE

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RMB	RECIRCULATION RING HEADER - LOOP B	0 4/11/80	A16

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				WELD CAP	R&W A403-WP304W-67 FROM A240	3	K51404-4D	0.050						
RMB-J1	16	Cp-Hdr	SW								θ→		0.96	SHOP WATER SPRAY COOLED
				RING HEADER (11-1)	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	0.059						RISER OUTLETS EXTRUDED PRIOR TO HEAT TREATMENT
RMB-J6	16	Hdr-Cr	SW								θ→		1.45	SHOP WATER SPRAY COOLED
				REDUCING CROSS 22X22X16X16	R&W A403-WP304W FROM A240-69	2	6825331	0.040						ALSO SHOWN ON PG. B14
RMB-J8	16	Cr-Hdr	SW								θ→		1.35	SHOP WATER SPRAY COOLED
				RING HEADER (11-2)	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	0.059						RISER OUTLETS EXTRUDED PRIOR TO HEAT TREATMENT
RMB-J12	16	Hdr-Cp	SW								θ→		0.96	SHOP WATER SPRAY COOLED
				WELD CAP	R&W A403-WP304W-67 FROM A240	3	K51404-4D	0.050						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRA	RECIRCULATION RISERS - LOOP B (N2A)	0 4/11/80	A17

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (11-2)	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	0.059						SPOOL 11-2 ALSO SHOWN ON PG. A16
RMB-J11	10	Hdr-A	SW								X		1.95	
				ADAPTER	FORGED A182-F304	6	52624	0.070						
RRA-J7	10	A-P	FW								X		1.16	
				PIPE (16-2)	SMLS A376 - TP304	5	2P3687	0.051						
RRA-J5	10	P-E	SW								X		1.57	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061						
RRA-J4	10	E-P	SW								X		1.63	
				PIPE (16-1)	SMLS A376-TP304	5	2P3399	0.055						
RRA-J4A	10	P-P	FW								X		0.98	
				PIPE (16-1)	SMLS A376-TP304	5	2P3399	0.055						PORTION OF SPOOL 16-1 WAS CUT OUT AND REPLACED IN 1978
RRA-J3	10	P-P	FW								X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030						
RRA-F2A	10	P-SE	FW									X	1.02	
				SAFE-END (N2A)	SMLS SB-166 INCONEL	7	NX9923	0.06						SAFE-END REPLACED IN 1978
RRA-F2	10	SE-NOZ	FW									X	1.03	
				RECIRC. INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRB	RECIRCULATION RISERS - LOOP B (N2B)	0 4/11/80	A18

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (11-2)	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	0.059						SPOOL 11-2 ALSO SHOWN ON PG. A16
RRB-J9	10	Hdr-A	SW								X		2.19	
				ADAPTER	FORGED A182-F304	6	52624	0.070						
RRB-J7	10	A-P	FW								X		1.25	
				PIPE (17-2)	SMLS A376 - TP304	5	2P3687	0.051						
RRB-J5	10	P-E	SW								X		1.75	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061						
RRB-J4	10	E-P	SW								X		1.59	
				PIPE (17-1)	SMLS A376 - TP304	5	2P3399	0.055						
RRB-J4A	10	P-P	FW								X		0.98	
				PIPE (17-1)	SMLS A376 - TP304	5	2P3399	0.055						PORTION OF SPOOL 17-1 WAS CUT OUT AND REPLACED IN 1978
RRB-J3	10	P-P	FW								X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030						
RRB-F2A	10	P-SE	FW									X	1.02	
				SAFE-END (N2B)	SMLS SB-166 INCONEL	7	NX9923	0.06						SAFE-END REPLACED IN 1978
RRB-F2	10	SE-NOZ	FW									X	1.03	
				RECIRC. INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						

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STRESS CORROSION CRACKING EVALUATION

DUANE ARNOLD ENERGY CENTER

Prepared by **nutech**

LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRC	RECIRCULATION RISERS - LOOP B (N2C)	0 4/11/80	A19

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (11-1)	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	0.059						SPOOL 11-1 ALSO SHOWN ON PG. A16
RMB-J5	10	Hdr-A	SW								X		2.10	
				ADAPTER	FORGED A182-F304	6	52624	0.070						
RRC-J7	10	A-P	FW								X		1.24	
				PIPE (18-2)	SMLS A376 TP304	5	2P3687	0.051						
RRC-J5	10	P-E	SW								X		1.73	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061						
RRC-J4	10	E-P	SW								X		1.40	
				PIPE (18-1)	SMLS A376-TP304	5	2P3399	0.055						
RRC-J4A	10	P-P	FW								X		0.98	
				PIPE (18-1)	SMLS A376-TP304	5	2P3399	0.055						PORTION OF SPOOL 18-1 WAS CUT OUT AND REPLACED IN 1978
RRC-J3	10	P-P	FW								X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030						
RRC-F2A	10	P-SE	FW									X	1.02	
				SAFE-END (N2C)	SMLS SB-166 INCONEL	7	NX9923	0.06						SAFE-END REPLACED IN 1978
RRC-F2	10	SE-NOZ	FW									X	1.03	
				RECIRC. INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RRD	RECIRCULATION RISERS - LOOP B (N2D)	0 4/11/80	A20

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV SENS	NUREG 0313 STATUS: NON CONF	NUREG 0313 STATUS: CONF	STRESS RULE INDEX	COMMENTS
				16" RING HEADER (11-1)	R&W A358 CL.1 FROM A240-67 T304	1	600120-1B	0.059					SPOOL 11-1 ALSO SHOWN ON PG. A16
RMB-J2	10	Hdr-A	SW							X		1.83	
				ADAPTER	FORGED A182-F304	6	52624	0.070					
RRD-J7	10	A-P	FW							X		1.13	
				PIPE (19-2)	SMLS A376-TP304	5	2P3687	0.051					
RRD-J5	10	P-E	SW							X		1.58	
				ELBOW(90°LR)	R&W A403-WP304W-67 FROM A240	3	37845-1A	0.061					
RRD-J4	10	E-P	SW							X		1.44	
				PIPE (19-1)	SMLS A376-TP304	5	2P3399	0.055					
RRD-J4A	10	P-P	FW							X		0.98	
				PIPE (19-1)	SMLS A376-TP304	5	2P3399	0.055					PORTION OF SPOOL 17-1 WAS CUT OUT AND REWELDED IN 1978
RRD-J3	10	P-P	FW							X		1.23	
				SAFE-END EXTENSION	FORGED SA-336 GR. F8	7	M53S	0.030					
RRD-F2A	10	P-SE	FW								X	1.02	
				SAFE-END (N2D)	SMLS SB-166 INCONEL	7	NX9923	0.06					SAFE-END REPLACED IN 1978
RRD-F2	10	SE-NOZ	FW								X	1.03	
				RECIRC. INLET NOZZLE	FORGED SA-508 CL.2 LOW ALLOY STEEL	---	NA	---					

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RBB	RECIRCULATION BYPASS LINE - LOOP B	0 4/11/80	A21

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREATMENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV / SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				WELDOLET 22"X4"	FORGED A182-F304	6	812680 (496E)	0.060					ALSO SHOWN ON PG. A15
RBB-J1	4	WOL-P	FW						X	X		1.23	
				PIPE	SMLS A376-TP304	5	2P3371	0.057					
RBB-J2	4	P-E	SW						X	X		1.39	
				ELBOW(90°LR)	SMLS A403-WP304W-67 FROM A312	3	20257 CFRO	0.047					
RBB-J3	4	E-P	SW						X	X		1.50	
				PIPE	SMLS A376-TP304	5	2P3371	0.057					
RBB-J6	4	P-T	FW						X	X		1.86	
				TEE	SMLS A403-WP304W-67 FROM A312	3	37368 CFRP	0.060					
RBB-J7	4	T-FL	SW						X	X		1.29	
				WN FLANGE (900#-LONG)	FORGED A182-F316	4	E1460	0.060					
				BLIND FLANGE	FORGED A182-F316	4	E1460	0.060					
				TEE	SMLS A403-WP304W-67 FROM A312	3	37368 CFRP	0.060					ALSO SHOWN ON PG. A14
RBB-J8	4	T-P	FW						X	X		1.99	
				PIPE	SMLS A376-TP304	5	2P3371	0.057					
RBB-J9	4	P-E	SW						X	X		1.73	

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RBB	RECIRCULATION BYPASS LINE - LOOP B (CON'T)	0 4/11/80	A22

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				ELBOW(90°LR)	SMLS A403-WP304W-67 FROM A376	3	20257 CFRO	0.047						
RBB-J10	4	E-V	FW						θ+		X		1.52	LOWER %C TO CASTING HIGH RESISTANCE TO IGSCC
				VALVE (MO-F032A)	CAST A351-65 GR. CF8	7	41706	0.08						8% FERRITE
RBB-J12	4	V-WOL	FW						X		X		1.25	
				WELDOLET 22"X4"	FORGED A182-F304	6	812680 (496E)	0.060						ALSO SHOWN ON PG. A15

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RHB	RESIDUAL HEAT REMOVAL - LOOP B	0 4/11/80	B1

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV SENS	NUREG 0313 STATUS NON CONF	NUREG 0313 STATUS CONF	STRESS RULE INDEX	COMMENTS
				22"x22"x18" TEE	R&W A403 - WP 304 W FROM A240	2	6003241	0.055					TEE ALSO SHOWN ON PG. A12 "B" RECIRC SUCTION LINE
RHB-J1	18	T-P	FW							X		1.18	
				PIPE (P1)	R&W A358 TP304 CL. 1	4	328258	0.033					
RHB-F3	18	P-P	SW								X	0.82	
				PIPE (P2)	SMLS A333 GR. 6 CARBON STEEL	---	NA	---					
				PIPE (P1)	R&W A358 TP304 CL. 1	7	328258	0.033					
RHB-J2	4	BPC	SW							X			
		(P-WOL)		WELDOLET 18"x4"	FORGED A182 F304	7	110G	0.05					BRANCH CONNECTION FOR 4" CLEAN-UP SUCTION LINE

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RHC	RESIDUAL HEAT REMOVAL - LOOP A (20A)	0 4/11/80	B2

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS SERV	SENS	NON CONF	CONF	STRESS RULE INDEX	COMMENTS
				22x22x20" TEE	R&W A403-WP 304 W FROM A240	2	6003241	0.055						TEE ALSO SHOWN ON PG. A3 "A" RECIRC DISCHARGE LINE
RHC-J1	20	T-P	FW								X		1.28	
				PIPE (P1)	R&W A358 TP304 CL. 1	7	318435	0.060						
RHC-F2	20	P-P	SW								X		0.84	
				PIPE (P2)	SMLS A333 GR. 6 CARBON STEEL	---	NA	---						

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LINE NO.	SYSTEM	REVISION - DATE	PAGE
RHD	RESIDUAL HEAT REMOVAL - LOOP B (20B)	0 4/11/80	B3

WELD NUMBER	DIA. (IN)	WELD TYPE	SHOP OR FIELD WELD	COMPONENT	MATERIAL TYPE & SPECIFICATION	HEAT TREAT-MENT	HEAT NUMBER	CARBON CONTENT (%)	NUREG 0313 STATUS: SERV SENS	NUREG 0313 STATUS: NON CONF	NUREG 0313 STATUS: CONF	STRESS RULE INDEX	COMMENTS
				22"x22"x20" TEE	EXTRUDED A403 - WP304W FROM A240	2	6825331	0.040					TEE ALSO SHOWN ON PG. A14 "B" RECIRC DISCHARGE LINE
RHD-J1	20	T-P	FW							X		1.29	
				PIPE (P1)	R&W A358 TP304 CL. 1	7	318435	0.060					
RHD-F2	20	P-P	SW							X		0.84	
				PIPE (P2)	SMLS A333 GR. 6 CARBON STEEL	---	NA	---					

APPENDIX B

STRESS RULE INDEX EVALUATION SUMMARY

S C O R E

-- VERSION 1.0.0 --

KEY FOR STRESS RULE INDEX EVALUATION - SUMMARY

ISI	ISI Weld Number
WELD ID	Pipe Fabricator's Weld Number
WELD TYPE	Components Adjoining Weld
PIPE SIZE	Pipe Diameter (in.)
NODE NO	NSC Stress Analysis Mode Number
COMP TYPE	Component Type Used in Determining NB-3600 Piping Stress Indices

---

B1 / B2	NB-3600 Piping Stress Indices
C1 / C2	NB-3600 Piping Stress Indices
K1 / K2	NB-3600 Piping Stress Indices
SI(PRES)	Pressure Stress Intensity (psi)
SI (DW)	Dead Weight Stress Intensity (psi)
SI(THER)	Thermal Stress Intensity (psi)
PM + PB	Primary Stress Intensity (psi)
PM+PB+Q+F	Primary plus Secondary plus Peak Stress Intensity (psi)
Q + F	Secondary plus Peak Stress Intensity (psi)
RESI ST	Weld Residual Stress (psi)
YIELD ST	Code Minimum Yield Strength of Piping Material at 550°F (psi)
MOD. ELA.	Young's Modulus of Piping Material (psi)

SRI,PRI	Stress Rule Index - Primary Stress Component
SRI,SEC	Stress Rule Index - Secondary Stress Component

SRI TOTAL	Overall Stress Rule Index

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCA-J3 A1	RCA-J4 RS-N-A1-A	RCA-J5 RS-N-A1-B	RCA-J6 A2	RCA-J7 RS-N-A2-C
WELD TYPE	SE-P	P-E	E-P	P-P	P-P
PIPE SIZE	22.00	22.00	22.00	22.00	22.00
NODE NO	10A	15A	20A	A2	SNA2C
COMP TYPE	TRANS	ELBOWLR	ELBOWLR	PIPE	PIPE
B1 / B2	.50/1.00	1.00/3.52	1.00/3.52	.50/1.00	.50/1.00
C1 / C2	1.37/1.50	1.23/4.70	1.23/4.70	1.10/1.00	1.10/1.00
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12388.70	12388.70	12388.70	12388.70	12388.70
SI (DW)	716.42	140.12	344.64	215.70	0.00
SI(THER)	1145.68	1038.97	699.63	543.29	0.00
PM + PB	6910.78	12882.15	13602.37	6410.06	6194.35
PM+PB+Q+F	25432.10	28324.31	27184.80	17719.27	16353.09
Q + F	18521.33	15442.16	13582.43	11309.22	10158.74
RESI ST	28000.00	28000.00	28000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.3676	.6852	.7235	.3410	.3295
SRI,SEC	.6633	.6194	.5929	.5605	.5441
SRI TOTAL	1.0309	1.3047	1.3164	.9015	.8736

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCA-J12 RS-N-A2-B	RCA-J13 A3	RCA-J15 A4	RCA-J18 RS-N-A3-A	RCA-J21 RS-N-A3-D
WELD TYPE	P-E	E-V	V-P	BPC	P-E
PIPE SIZE	22.00	22.00	22.00	22.00	22.00
NODE NO	35A	40A	55A	60A	65A
COMP TYPE	ELBOWLR	ELBOWLR	TRANS	BRANRUN	ELBOWSR
B1 / B2	1.00/3.52	1.00/3.52	.50/1.00	1.00/1.00	1.00/4.62
C1 / C2	1.23/4.70	1.23/4.70	1.37/1.50	2.00/1.00	1.46/6.15
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12388.70	12388.70	12388.70	12388.70	12388.70
SI (DW)	412.59	481.50	176.64	63.29	504.37
SI(THER)	402.18	507.15	450.15	440.38	431.85
PM + PB	13841.66	14084.37	6371.00	12452.00	14716.48
PM+PB+Q+F	25245.06	26714.77	22102.43	30639.51	32083.63
Q + F	11403.39	12630.40	15731.44	18187.51	17367.16
RESI ST	28000.00	28000.00	28000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI.PRI	.7363	.7492	.3389	.6623	.7828
SRI.SEC	.5618	.5793	.6236	.6586	.6469
SRI TOTAL	1.2981	1.3285	.9624	1.3209	1.4297

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCA-J22 A5	RCA-J24 A6	RCA-J27 RD-A-A1-A	RCA-J28 A7	RCA-J30 A8
WELD TYPE	E-PP	PP-P	BPC	P-V	V-E
PIPE SIZE	22.00	22.00	6.00	22.00	22.00
NODE NO	70A	90A	95A	100A	115A
COMP TYPE	ELBOWSR	TRANS	TEE	TRANS	ELBOWLR
B1 / B2	1.00/4.62	.50/1.00	1.00/2.35	.50/1.00	1.00/3.18
C1 / C2	1.46/6.15	1.36/1.48	1.50/3.13	1.36/1.48	1.23/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12388.70	12748.55	3987.40	12748.55	12748.55
SI (DW)	1061.17	294.64	179.63	94.27	227.62
SI(THER)	526.47	436.32	2766.79	365.14	505.85
PM + PB	17286.24	6668.91	4409.40	6468.55	13472.78
PM+PB+Q+F	39299.10	22814.02	23790.24	22088.29	24459.25
Q + F	22012.85	16145.10	19380.84	15619.74	10986.46
RESI ST	28000.00	28000.00	39000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI.PRI	.9195	.3547	.2345	.3441	.7166
SRI.SEC	.7131	.6295	.8324	.6220	.5559
SRI TOTAL	1.6326	.9842	1.0670	.9660	1.2725

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCA-J32 RD-N-A2-A	RCA-J34 RD-N-A2-B	RBA-J1 A18	RBA-J2 RD-N-A8-A	RBA-J3 RD-N-A8-B
WELD TYPE	E-P	BPC	WOL-P	P-E	E-P
PIPE SIZE	22.00	6.00	4.00	4.00	4.00
NODE NO	120A	125A	A18	130A	135A
COMP TYPE	ELBOWLR	TEE	PIPE	ELBOWLR	ELBOWLR
B1 / B2	1.00/3.18	1.00/2.35	.50/1.00	1.00/2.43	1.00/2.43
C1 / C2	1.23/4.24	1.50/3.13	1.10/1.00	1.27/3.24	1.27/3.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12748.55	3987.40	8031.90	8031.90	8031.90
SI (DW)	208.79	1115.00	591.19	76.24	155.46
SI(THER)	444.87	2860.58	9106.68	3049.46	4088.63
PM + PB	13412.87	6606.90	4607.14	8217.26	8409.89
PM+PB+Q+F	23849.85	29593.08	28058.27	30437.64	36963.89
Q + F	10436.99	22986.19	23451.13	22220.38	28554.00
RESI ST	28000.00	39000.00	45000.00	45000.00	45000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.7135	.3514	.2451	.4371	.4473
SRI,SEC	.5441	.8839	.9760	.9585	1.0488
SRI TOTAL	1.2615	1.2353	1.2211	1.3956	1.4961

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RBA-J6 A19	RBA-J8 A20	RBA-J7 RD-N-A9-A	RBA-J9 RD-N-A10-A	RBA-J10 A21
WELD TYPE	P-T	T-P	T-FL	P-E	E-V
PIPE SIZE	4.00	4.00	4.00	4.00	4.00
NODE NO	140A	140A	140A	150A	155A
COMP TYPE	TEE	TEE	TEE	ELBOWLR	ELBOWLR
B1 / B2	1.00/1.69	1.00/1.69	1.00/1.69	1.00/2.43	1.00/2.43
C1 / C2	1.50/2.26	1.50/2.26	1.50/2.26	1.27/3.24	1.27/3.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	8031.90	8031.90	8031.90	8031.90	8031.90
SI (DW)	459.35	1446.17	0.00	740.30	405.85
SI(THER)	10590.04	10406.92	0.00	5588.41	3889.88
PM + PB	8809.42	10479.74	8031.90	9831.86	9018.69
PM+PB+Q+F	59343.71	62608.58	14457.42	49128.28	37265.23
Q + F	50534.30	52128.83	6425.52	39296.42	28246.54
RESI ST	45000.00	45000.00	45000.00	45000.00	45000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.4686	.5574	.4272	.5230	.4797
SRI,SEC	1.3622	1.3849	.7333	1.2020	1.0444
SRI TOTAL	1.8308	1.9424	1.1605	1.7249	1.5241

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RBA-J12 A22	RCA-J38 RD-N-A2-E	RCA-J41 RD-N-A2-C	RCA-J43 A9	RMA-J6 RD-N-A3-E
WELD TYPE	V-WOL	P-P	P-T	T-CR	CR-CP
PIPE SIZE	4.00	22.00	22.00	22.00	22.00
NODE NO	167A	173A	175A	180A	185A
COMP TYPE	TRANS	PIPE	TEE	TEE	TEE
B1 / B2	.50/1.00	.50/1.00	1.00/2.35	1.00/2.35	1.00/2.35
C1 / C2	1.34/1.45	1.10/1.00	1.50/3.13	1.50/3.13	1.50/3.13
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	8031.90	12748.55	12748.55	12748.55	12748.55
SI (DW)	1623.18	5.23	98.48	398.75	0.00
SI(THER)	5460.72	195.91	219.90	511.41	0.00
PM + PB	5639.13	6379.51	12979.91	13685.35	12748.55
PM+PB+Q+F	31448.36	17190.16	24742.49	28079.18	22947.40
Q + F	25809.23	10810.65	11762.59	14393.84	10198.84
RESI ST	45000.00	28000.00	28000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI.PRI	.3000	.3393	.6904	.7279	.6781
SRI.SEC	1.0097	.5534	.5670	.6045	.5447
SRI TOTAL	1.3096	.8927	1.2574	1.3324	1.2228

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RMA-J2 RD-N-A3-B	RRH-J7 A13	RMA-J1 RD-N-A3-A	RRH-J5 RD-N-A7-B	RRH-J4 RD-N-A7-C
WELD TYPE	HDR-A	A-P	CP-HDR	P-E	E-P
PIPE SIZE	10.00	10.00	16.00	10.00	10.00
NODE NO	215A	ADATR	220A	225A	230A
COMP TYPE	TEE	PIPE	TRANS	ELBOWLR	ELBOWLR
B1 / B2	1.00/2.31	.50/1.00	.50/1.00	1.00/3.18	1.00/3.18
C1 / C2	1.50/3.09	1.10/1.00	1.36/1.48	1.26/4.24	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	11930.12	11930.12	12482.49	11930.12	11930.12
SI (DW)	135.20	133.65	0.00	158.63	132.51
SI(THER)	7874.17	7874.17	0.00	2840.50	3098.50
PM + PB	12243.10	6098.71	6241.25	12434.55	12351.48
PM+PB+Q+F	65971.68	30161.83	20405.23	40896.90	42666.56
Q + F	53728.58	24063.12	14163.98	28462.35	30315.08
RESI ST	33500.00	33500.00	30000.00	33500.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.6512	.3244	.3320	.6614	.6570
SRI,SEC	1.2438	.8208	.6297	.8835	.9099
SRI TOTAL	1.8950	1.1452	.9617	1.5449	1.5669

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RMA-J7 RD-N-A3-F	RMA-J8 RD-N-A3-G	RRF-J7 A11	RRF-J5 RD-N-A5-B	RRF-J4 RD-N-A5-C
WELD TYPE	CR-HOR	HOR-A	A-P	P-E	E-P
PIPE SIZE	16.00	10.00	10.00	10.00	10.00
NODE NO	237A	240A	ADATR	245A	250A
COMP TYPE	TEE	TEE	PIPE	ELBOWLR	ELBOWLR
B1 / B2	1.00/2.35	1.00/2.31	.50/1.00	1.00/3.18	1.00/3.18
C1 / C2	1.50/3.13	1.50/3.09	1.10/1.00	1.26/4.24	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12482.49	11930.12	11930.12	11930.12	11930.12
SI (DW)	145.50	882.20	882.20	612.61	218.54
SI(THER)	1380.76	8263.53	8263.53	3276.00	1492.08
PM + PB	12824.32	13972.29	6847.26	13878.17	12625.06
PM+PB+Q+F	31074.07	72284.89	32210.06	47685.28	31063.16
Q + F	18249.76	58312.60	25362.80	33807.11	18438.10
RESI ST	30000.00	33500.00	33500.00	33500.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.6821	.7432	.3642	.7382	.6715
SRI,SEC	.6880	1.3091	.8393	.9597	.7406
SRI TOTAL	1.3701	2.0523	1.2035	1.6979	1.4121

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RMA-J5 RD-N-A3-D	RMA-J4 RD-N-A3-C	RRG-J7 A12	RRG-J5 RD-N-A6-B	RRG-J4 RD-N-A6-C
WELD TYPE	HDR-CR	HDR-A	A-P	P-E	E-P
PIPE SIZE	16.00	10.00	10.00	10.00	10.00
NODE NO	187A	190A	ADATR	195A	200A
COMP TYPE	TEE	TEE	PIPE	ELBOWLR	ELBOWLR
B1 / B2	1.00/2.35	1.00/2.31	.50/1.00	1.00/3.18	1.00/3.18
C1 / C2	1.50/3.13	1.50/3.09	1.10/1.00	1.26/4.24	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12482.49	11930.12	11930.12	11930.12	11930.12
SI (DW)	167.25	870.40	870.40	567.81	227.12
SI(THER)	1941.48	9150.02	9150.02	3204.63	2603.61
PM + PB	12875.42	13944.97	6835.46	13735.73	12652.34
PM+PB+Q+F	34358.26	77144.38	33784.50	46798.68	39611.68
Q + F	21482.84	63199.40	26949.04	33062.95	26959.33
RESI ST	30000.00	33500.00	33500.00	33500.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI.PRI	.6849	.7418	.3636	.7306	.6730
SRI.SEC	.7341	1.3788	.8619	.9491	.8621
SRI TOTAL	1.4189	2.1206	1.2255	1.6797	1.5351

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RMA-J10 RD-N-A3-H	RRE-J7 A10	RMA-J11 RD-N-A3-J	RRE-J5 RD-N-A4-B	RRE-J4 RD-N-A4-C
WELD TYPE	HDR-A	A-P	HDR-CP	P-E	E-P
PIPE SIZE	10.00	10.00	16.00	10.00	10.00
NODE NO	265A	ADATR	270A	275A	280A
COMP TYPE	TEE	PIPE	TRANS	ELBOWLR	ELBOWLR
B1 / B2	1.00/2.31	.50/1.00	.50/1.00	1.00/3.18	1.00/3.18
C1 / C2	1.50/3.09	1.10/1.00	1.36/1.48	1.26/4.24	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	11930.12	11930.12	12482.49	11930.12	11930.12
SI (DW)	169.86	169.86	0.00	122.30	27.31
SI(THER)	6357.08	6357.08	0.00	3020.30	1726.56
PM + PB	12323.31	6134.91	6241.25	12319.01	12016.96
PM+PB+Q+F	57735.75	27496.24	20405.23	41991.79	31393.27
Q + F	45412.44	21361.33	14163.98	29672.78	19376.30
REST ST	33500.00	33500.00	30000.00	33500.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.6555	.3263	.3320	.6553	.6392
SRI,SEC	1.1252	.7823	.6297	.9008	.7540
SRI TOTAL	1.7807	1.1086	.9617	1.5560	1.3932

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCB-J3 B1	RCB-J4 RS-N-B1-A	RCB-J5 RS-N-B1-B	RCB-J6 B2	RCB-J7 RS-N-B2-A
WELD TYPE	SE-P	P-E	E-P	P-T	T-P
PIPE SIZE	22.00	22.00	22.00	22.00	22.00
NODE NO	108	158	208	238	238
COMP TYPE	TRANS	ELBOWLR	ELBOWLR	TEE	TEE
B1 / B2	.50/1.00	1.00/3.52	1.00/3.52	1.00/2.59	1.00/2.59
C1 / C2	1.37/1.50	1.23/4.70	1.23/4.70	1.50/3.45	1.50/3.45
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12388.70	12388.70	12388.70	12388.70	12388.70
SI (DW)	628.10	390.10	59.94	0.00	377.71
SI(THER)	843.00	866.06	680.35	400.09	577.96
PM + PB	6822.45	13762.48	12599.78	12388.70	13366.67
PM+PB+Q+F	24378.17	28975.73	24615.61	24785.84	28238.21
Q + F	17555.72	15213.25	12015.83	12397.14	14871.54
RESI ST	28000.00	28000.00	28000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.3629	.7320	.6702	.6590	.7110
SRI,SEC	.6496	.6162	.5706	.5760	.6113
SRI TOTAL	1.0125	1.3482	1.2408	1.2350	1.3223

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCB-J9 RS-N-B2-A1	RCB-J15 RS-N-B2-E	RCB-J16 B3	RCB-J18 B4	RCB-J21 RS-N-B3-A
WELD TYPE	P-P	P-E	E-V	V-P	BPC
PIPE SIZE	22.00	22.00	22.00	22.00	22.00
NODE NO	NB2A1	35B	40B	55B	60B
COMP TYPE	PIPE	ELBOWLR	ELBOWLR	TRANS	BRANRUN
B1 / B2	.50/1.00	1.00/3.52	1.00/3.52	.50/1.00	1.00/1.00
C1 / C2	1.10/1.00	1.23/4.70	1.23/4.70	1.37/1.50	2.00/1.00
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12388.70	12388.70	12388.70	12388.70	12388.70
SI (DW)	110.77	352.63	465.27	211.92	103.13
SI(THER)	386.75	610.02	506.64	379.84	345.30
PM + PB	6305.13	13630.52	14027.21	6406.27	12491.83
PM+PB+Q+F	17248.63	26495.02	26573.34	22007.99	30540.06
Q + F	10943.51	12864.50	12546.12	15601.72	18048.23
RESI ST	28000.00	28000.00	28000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.3354	.7250	.7461	.3408	.6645
SRI,SEC	.5553	.5827	.5781	.6217	.6566
SRI TOTAL	.8907	1.3077	1.3243	.9625	1.3211

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCB-J24 RS-N-B3-D	RCB-J25 B5	RCB-J27 B6	RCB-J30 RD-N-B1-A	RCB-J31 B7
WELD TYPE	P-E	E-PP	PP-P	BPC	P-V
PIPE SIZE	22.00	22.00	22.00	6.00	22.00
NODE NO	658	708	908	958	1008
COMP TYPE	ELBOWSR	ELBOWSR	TRANS	TEE	TRANS
B1 / B2	1.00/4.62	1.00/4.62	.50/1.00	1.00/2.35	.50/1.00
C1 / C2	1.46/6.15	1.46/6.15	1.36/1.48	1.50/3.13	1.36/1.48
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12388.70	12388.70	12748.55	3987.40	12748.55
SI (DW)	445.10	975.82	253.73	199.77	48.20
SI(THER)	277.13	335.77	226.75	2873.99	231.29
PM + PB	14442.93	16892.31	6628.00	4456.73	6422.48
PM+PB+Q+F	29713.34	36241.40	22144.58	24508.27	21607.42
Q + F	15270.41	19349.09	15516.58	20051.54	15184.95
RESI ST	28000.00	28000.00	28000.00	39000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.7682	.8985	.3526	.2371	.3416
SRI,SEC	.6170	.6751	.6205	.8420	.6158
SRI TOTAL	1.3852	1.5737	.9730	1.0791	.9574

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RBB-J3 RD-N-BB-B	RBB-J6 B19	RBB-J8 B20	RBB-J7 RD-N-B9-A	RBB-J9 RD-N-B10-A
WELD TYPE	E-P	P-T	T-P	T-FL	P-E
PIPE SIZE	4.00	4.00	4.00	4.00	4.00
NODE NO	1358	1408	1408	1458	1508
COMP TYPE	ELBOWLR	TEE	TEE	TEE	ELBOWLR
B1 / B2	1.00/2.43	1.00/1.69	1.00/1.69	1.00/1.69	1.00/2.43
C1 / C2	1.27/3.24	1.50/2.26	1.50/2.26	1.50/2.26	1.27/3.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	8031.90	8031.90	8031.90	8031.90	8031.90
SI (DW)	173.68	477.39	1562.36	1029.63	746.35
SI(THER)	4147.79	11066.86	10910.63	0.00	5674.30
PM + PB	8454.18	8839.95	10676.40	9774.68	9846.56
PM+PB+Q+F	37415.41	61353.99	65126.83	18640.10	49664.76
Q + F	28961.22	52514.04	54450.43	8865.41	39818.20
RESI ST	45000.00	45000.00	45000.00	45000.00	45000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.4497	.4702	.5679	.5199	.5238
SRI,SEC	1.0546	1.3904	1.4180	.7681	1.2094
SRI TOTAL	1.5043	1.8606	1.9859	1.2880	1.7332

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCB-J33 B8	RCB-J35 RD-N-B2-A	RCB-J37 RD-N-B2-B	RBB-J1 B18	RBB-J2 RD-N-B8-A
WELD TYPE	V-E	E-P	BPC	WOL-P	P-E
PIPE SIZE	22.00	22.00	6.00	4.00	4.00
NODE NO	115B	120B	125B	81B	130B
COMP TYPE	ELBOWLR	ELBOWLR	TEE	PIPE	ELBOWLR
B1 / B2	1.00/3.18	1.00/3.18	1.00/2.35	.50/1.00	1.00/2.43
C1 / C2	1.23/4.24	1.23/4.24	1.50/3.13	1.10/1.00	1.27/3.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12748.55	12748.55	3987.40	8031.90	8031.90
SI (OW)	223.04	172.81	1124.39	657.56	73.86
SI(THER)	246.12	175.00	2993.71	9459.36	3011.41
PM + PB	13458.21	13298.39	6628.94	4673.50	8211.47
PM+PB+Q+F	22440.95	21514.32	30396.60	28812.56	30201.72
Q + F	8982.74	8215.93	23767.66	24139.05	21990.24
RES1 ST	28000.00	28000.00	39000.00	45000.00	45000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.7159	.7074	.3526	.2486	.4368
SRI,SEC	.5273	.5164	.6950	.9858	.9552
SRI TOTAL	1.2432	1.2238	1.2476	1.2344	1.3920

STRESS RULE INDEX EVALUATION - SUMMARY

ISI	RBB-J10	RBB-J12	RCB-J41	RCB-J44	RCB-J46
WELD ID	B21	B22	RD-N-B2-E	RD-N-B2-C	B9
WELD TYPE	E-V	V-WOL	P-P	P-T	T-CR
PIPE SIZE	4.00	4.00	22.00	22.00	22.00
NODE NO	155B	167B	173B	175B	180B
COMP TYPE	ELBOWLR	TRANS	PIPE	TEE	TEE
B1 / B2	1.00/2.43	.50/1.00	.50/1.00	1.00/2.35	1.00/2.35
C1 / C2	1.27/3.24	1.34/1.45	1.10/1.00	1.50/3.13	1.50/3.13
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	8031.90	8031.90	12748.55	12748.55	12748.55
SI (DW)	413.40	1652.74	57.24	431.51	381.12
SI(THER)	3793.97	3769.66	492.65	1649.72	517.30
PM + PB	9037.03	5668.69	6431.52	13762.30	13643.93
PM+PB+Q+F	36749.58	27101.63	17817.90	34682.07	28013.04
Q + F	27712.55	21432.94	11386.38	20919.77	14369.11
RESI ST	45000.00	45000.00	28000.00	28000.00	28000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.4807	.3015	.3421	.7320	.7257
SRI,SEC	1.0368	.9473	.5616	.6975	.6041
SRI TOTAL	1.5175	1.2488	.9037	1.4296	1.3299

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RMB-J7 RD-N-B3-E	RMB-J6 RD-N-B3-D	RMB-J5 RD-N-B3-C	RRC-J7 B12	RRC-J5 RD-N-B6-B
WELD TYPE	CR-CP	HDR-CR	HDR-A	A-P	P-E
PIPE SIZE	22.00	16.00	10.00	10.00	10.00
NODE NO	1858	1878	1908	ADATR	1958
COMP TYPE	TEE	TEE	TEE	PIPE	ELBOWLR
B1 / B2	1.00/2.59	1.00/2.59	1.00/2.31	.50/1.00	1.00/3.18
C1 / C2	1.50/3.45	1.50/3.45	1.50/3.09	1.10/1.00	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	12748.55	12482.49	11930.12	11930.12	11930.12
SI (DW)	0.00	292.96	886.40	886.40	613.22
SI(THER)	0.00	1775.68	8875.73	9479.33	3591.54
PM + PB	12748.55	13241.01	13982.00	6851.45	13880.13
PM+PB+Q+F	22947.40	35323.04	75709.42	34406.06	50098.12
Q + F	10198.84	22082.03	61727.41	27554.61	36217.98
RESI ST	28000.00	30000.00	33500.00	33500.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.6781	.7043	.7437	.3644	.7383
SRI,SEC	.5447	.7426	1.3578	.8706	.9941
SRI TOTAL	1.2228	1.4469	2.1016	1.2350	1.7324

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RRC-J4 RD-N-B6-C	RMB-J2 RD-N-B3-B	RRD-J7 B13	RMB-J1 RD-N-B3-A	RRD-J5 RD-N-B7-B
WELD TYPE	E-P	HDR-A	A-P	CP-HDR	P-E
PIPE SIZE	10.00	10.00	10.00	16.00	10.00
NODE NO	2008	2158	ADATR	2208	2258
COMP TYPE	ELBOWLR	TEE	PIPE	TRANS	ELBOWLR
B1 / B2	1.00/3.18	1.00/2.31	.50/1.00	.50/1.00	1.00/3.18
C1 / C2	1.26/4.24	1.50/3.09	1.10/1.00	1.36/1.48	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	11930.12	11930.12	11930.12	12482.49	11930.12
SI (DW)	296.90	338.07	338.07	0.00	232.12
SI(THER)	1247.51	6603.35	6603.35	0.00	2974.12
PM + PB	12874.25	12712.71	6303.13	6241.25	12668.26
PM+PB+Q+F	29794.74	60038.48	28242.31	20405.23	42477.59
Q + F	16920.49	47325.77	21939.18	14163.98	29809.33
RESI ST	33500.00	33500.00	33500.00	30000.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.6848	.6762	.3353	.3320	.6738
SRI,SEC	.7189	1.1525	.7905	.6297	.9027
SRI TOTAL	1.4037	1.8287	1.1258	.9617	1.5766

STRESS RULE INDEX EVALUATION - SUMMARY

ISI	RRD-J4	RMB-J8	RMB-J9	RRB-J7	RRB-J5
WELD ID	RD-N-B7-C	RD-N-B3-F	RD-N-B3-G	B11	RD-N-B5-B
WELD TYPE	F-P	CR-MOR	MOR-A	A-P	P-E
PIPE SIZE	10.00	16.00	10.00	10.00	10.00
NODE NO	2308	2378	2408	ADATR	2458
COMP TYPE	ELBOWLR	TEE	TEE	PIPE	ELBOWLR
B1 / B2	1.00/3.18	1.00/2.35	1.00/2.31	.50/1.00	1.00/3.18
C1 / C2	1.26/4.24	1.50/3.13	1.50/3.09	1.10/1.00	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	11930.12	12482.49	11930.12	11930.12	11930.12
SI (DW)	82.51	52.84	827.30	827.28	659.58
SI(THER)	2013.67	1314.65	10130.23	10130.23	3617.92
PM + PB	12192.50	12606.63	13845.21	6792.34	14027.54
PM+PB+Q+F	34005.74	30178.88	82350.72	35471.28	50653.21
Q + F	21813.24	17572.25	68505.51	28678.94	36625.67
RESI ST	33500.00	30000.00	33500.00	33500.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.6485	.6706	.7364	.3613	.7461
SRI,SEC	.7887	.6783	1.4545	.8866	.9999
SRI TOTAL	1.4372	1.3489	2.1909	1.2479	1.7461

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RRB-J4 RD-N-B5-C	RMB-J11 RD-N-83-H	RRA-J7 810	RMB-J12 RD-N-83-J	RRA-J5 RD-N-84-B
WELD TYPE	E-P	HDR-A	A-P	HDR-CP	P-E
PIPE SIZE	10.00	10.00	10.00	16.00	10.00
NODE NO	2503	2658	ADATR	2708	2758
COMP TYPE	ELBOWLR	TEE	PIPE	TRANS	ELBOWLR
B1 / B2	1.00/3.18	1.00/2.31	.50/1.00	.50/1.00	1.00/3.18
C1 / C2	1.26/4.24	1.50/3.09	1.10/1.00	1.36/1.48	1.26/4.24
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	11930.12	11930.12	11930.12	12482.49	11930.12
SI (DW)	474.77	61.87	61.87	0.00	163.19
SI(THER)	2605.35	8729.46	8729.46	0.00	3099.86
PM + PB	13439.87	12073.34	6026.93	6241.25	12449.07
PM+PB+Q+F	41515.03	70315.97	31572.15	20405.23	42911.14
Q + F	28075.17	58242.63	25545.22	14163.98	30462.07
RESI ST	33500.00	33500.00	33500.00	30000.00	33500.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25666000.00	25666000.00	25666000.00	25666000.00	25666000.00
SRI,PRI	.7149	.6422	.3206	.3320	.6622
SRI,SEC	.8760	1.3081	.8419	.6297	.9120
SRI TOTAL	1.5929	1.9503	1.1625	.9617	1.5742

STRESS RULE INDEX EVALUATION - SUMMARY

ISI	RRA-J4
WELD ID	RD-N-54-C
WELD TYPE	E-P
PIPE SIZE	10.00
NODE NO	2808
COMP TYPE	ELBOWLR
B1 / B2	1.00/3.18
C1 / C2	1.26/4.24
K1 / K2	1.20/1.80
SI(PRES)	11930.12
SI (DW)	198.78
SI(THER)	3512.64
PM + PB	12562.23
PM+PB+Q+F	46333.02
Q + F	33770.80
RESI ST	33500.00
YIELD ST	14800.00
MOD. ELA.	25666000.00
SRI,PRI	.6682
SRI,SEC	.9592
SRI TOTAL	1.6274

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RRA/H-J4A	RRA/H-J3	RRA/H-F2A	RRA/H-F2A	RRA/H-F2
WELD TYPE	P-P	P-SEX	P-SE	P-SE	SE-NZ
PIPE SIZE	10.00	10.00	10.00	10.00	12.00
NODE NO	WELD5	WELD6	WELD4	WELD4	WELD2
COMP TYPE	PIPE	PIPE	TRANS	TRANS	TRANS
B1 / B2	.50/1.00	.50/1.00	.50/1.00	.50/1.00	.50/1.00
C1 / C2	1.10/1.00	1.10/1.00	1.36/1.48	1.35/1.46	1.34/1.45
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	9916.97	9916.97	9916.97	7757.14	6833.33
SI (DW)	673.30	3014.93	3251.25	2574.37	5185.24
SI(THER)	3283.88	7026.02	7442.46	5893.48	3431.22
PM + PB	5631.79	7973.41	8209.74	6452.94	8601.91
PM+PB+Q+F	20213.34	31164.11	44653.84	34819.26	33557.56
Q + F	14581.55	23190.69	36444.10	28366.32	24955.65
RESI ST	33500.00	33500.00	33500.00	40000.00	38000.00
YIELD ST	18800.00	18800.00	18800.00	28130.00	28130.00
MOD. ELA.	25778000.00	25778000.00	25778000.00	29416000.00	29416000.00
SRI,PRI	.2996	.4241	.4367	.2294	.3058
SRI,SEC	.6834	.8058	.9941	.7862	.7239
SRI TOTAL	.9830	1.2299	1.4308	1.0156	1.0297

STRESS RULE INDEX EVALUATION - SUMMARY

ISI WELD ID	RCA-F2	RCB-F2
WELD TYPE	SE-NZ	SE-NZ
PIPE SIZE	12.00	12.00
NODE NO	N1A	N1B
COMP TYPE	TRANS	TRANS
B1 / B2	.50/1.00	.50/1.00
C1 / C2	1.34/1.45	1.34/1.45
K1 / K2	1.20/1.80	1.20/1.80
SI(PRES)	6833.33	6833.33
SI (DW)	2085.38	1832.14
SI(THER)	2996.39	2292.12
PM + PB	5502.05	5248.81
PM+PB+Q+F	24302.30	21795.16
Q + F	18800.25	16546.35
RESI ST	32000.00	32000.00
YIELD ST	18800.00	18800.00
MOD. ELA.	25778000.00	25778000.00
SRI.PRI	.2927	.2792
SRI.SEC	.7220	.6900
SRI TOTAL	1.0147	.9692

STRESS RULE INDEX EVALUATION - SUMMARY

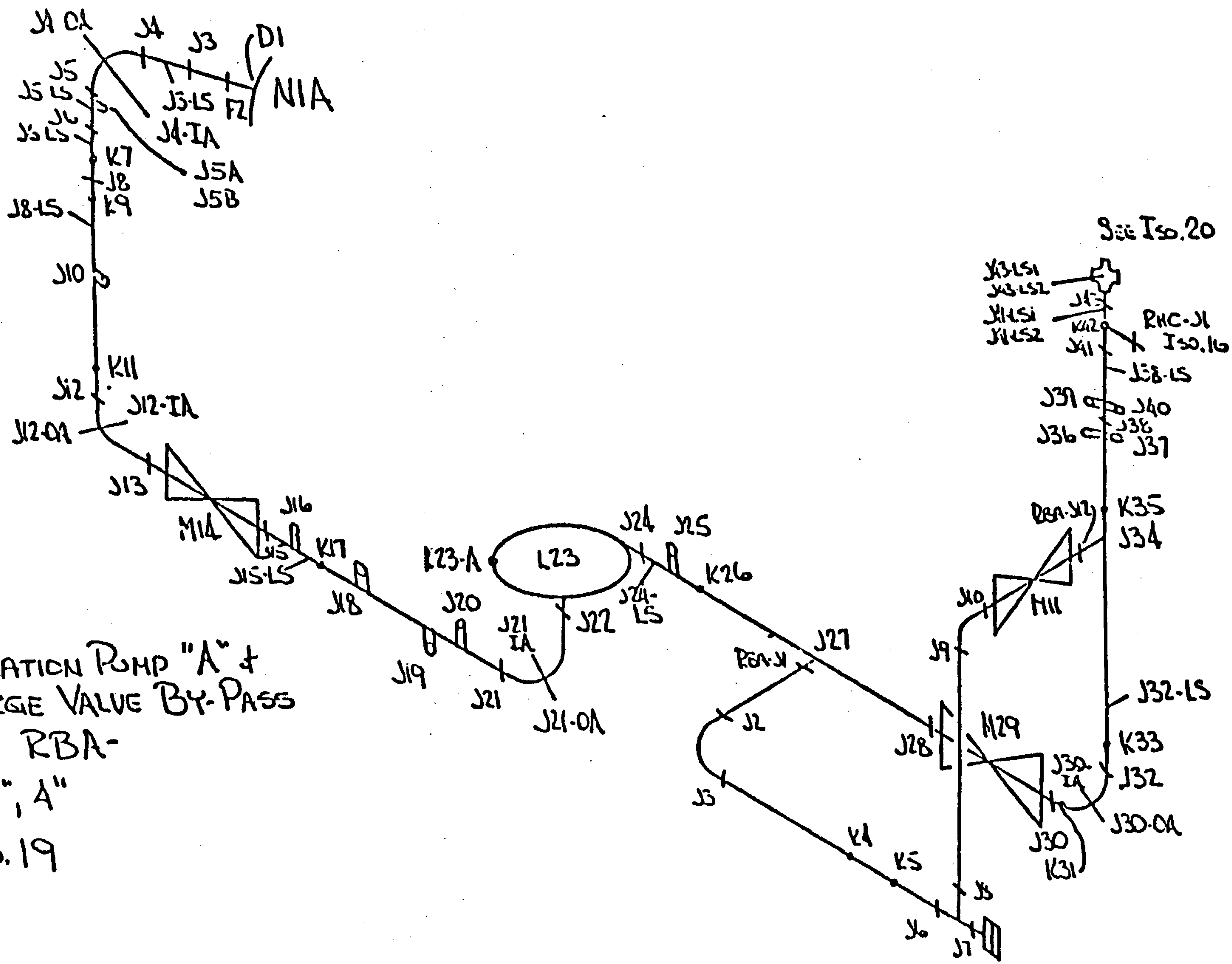
ISI WELD ID	RHC-J1	RHC-F2	RHB-J1	RHB-J2	RHB-F3
WELD TYPE	T-P	P-P	T-P	BP(P-WOL)	P-P
PIPE SIZE	20.00	20.00	18.00	18.00	18.00
NODE NO	175A	290A	238	410B	415B
COMP TYPE	TEE	PIPE	TEE	BRANRUN	PIPE
B1 / B2	1.00/2.59	.50/1.00	1.00/2.59	1.00/1.00	.50/1.00
C1 / C2	1.50/3.45	1.10/1.00	1.50/3.45	2.00/1.00	1.10/1.00
K1 / K2	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80	1.20/1.80
SI(PRES)	9699.32	9699.32	9605.12	9605.12	9605.12
SI (DW)	854.61	546.02	431.29	230.50	441.72
SI(THER)	1004.44	1064.68	769.18	517.63	461.25
PM + PB	11912.05	5395.68	10721.80	9835.62	5244.28
PM+PB+Q+F	29010.94	15702.35	24748.92	24398.92	14304.11
Q + F	17098.89	10306.67	14027.13	14563.30	9059.83
REST ST	28500.00	28500.00	29000.00	29000.00	29000.00
YIELD ST	18800.00	18800.00	18800.00	18800.00	18800.00
MOD. ELA.	25946000.00	25946000.00	25946000.00	25946000.00	25946000.00
SRI.PRI	.6336	.2870	.5703	.5232	.2790
SRI.SEC	.6450	.5490	.6087	.6162	.5384
SRI TOTAL	1.2787	.8360	1.1790	1.1394	.8173

STRESS RULE INDEX EVALUATION - SUMMARY

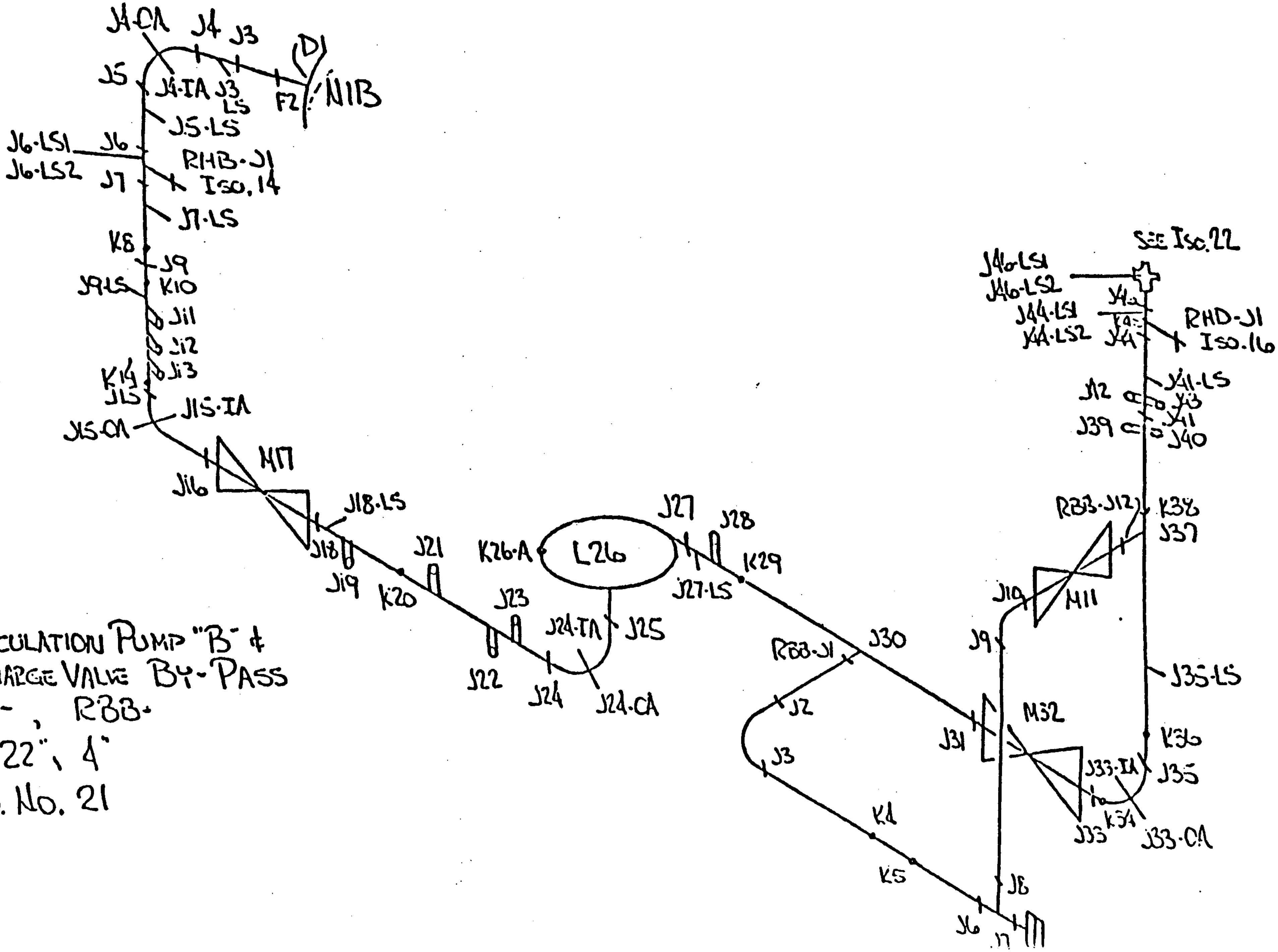
ISI WELD ID	RHD-J1	RHD-F2
WELD TYPE	T-P	P-P
PIPE SIZE	20.00	20.00
NODE NO	175B	290B
COMP TYPE	TEE	PIPE
B1 / B2	1.00/2.59	.50/1.00
C1 / C2	1.50/3.45	1.10/1.00
K1 / K2	1.20/1.80	1.20/1.80
SI(PRES)	9699.32	9699.32
SI (DW)	882.68	538.56
SI(THER)	1077.82	1128.25
PM + PB	11984.72	5388.22
PM+PB+Q+F	29641.28	15803.35
Q + F	17656.57	10415.14
REST ST	28500.00	28500.00
YIELD ST	18800.00	18800.00
MOD. ELA.	25946000.00	25946000.00
SRI,PRI	.6375	.2866
SRI,SEC	.6529	.5505
SRI TOTAL	1.2904	.8371

APPENDIX C

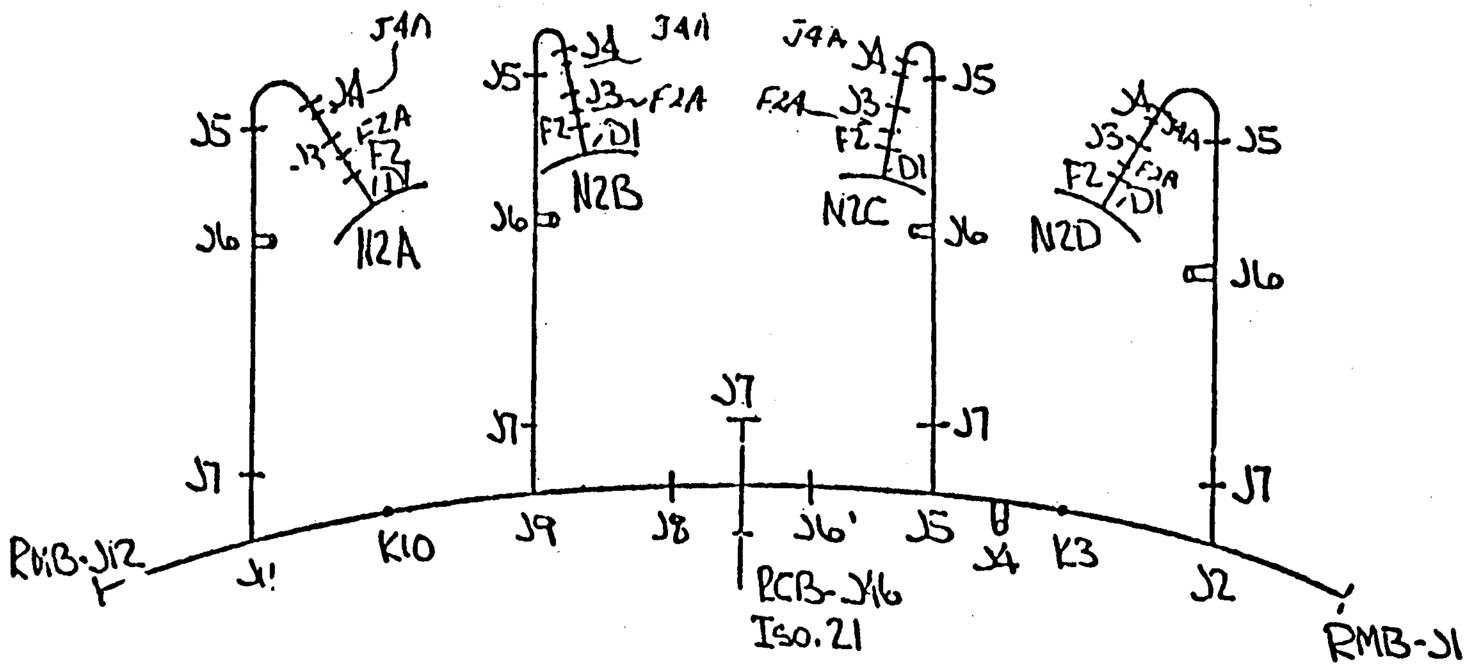
ISI ISOMETRIC DRAWINGS



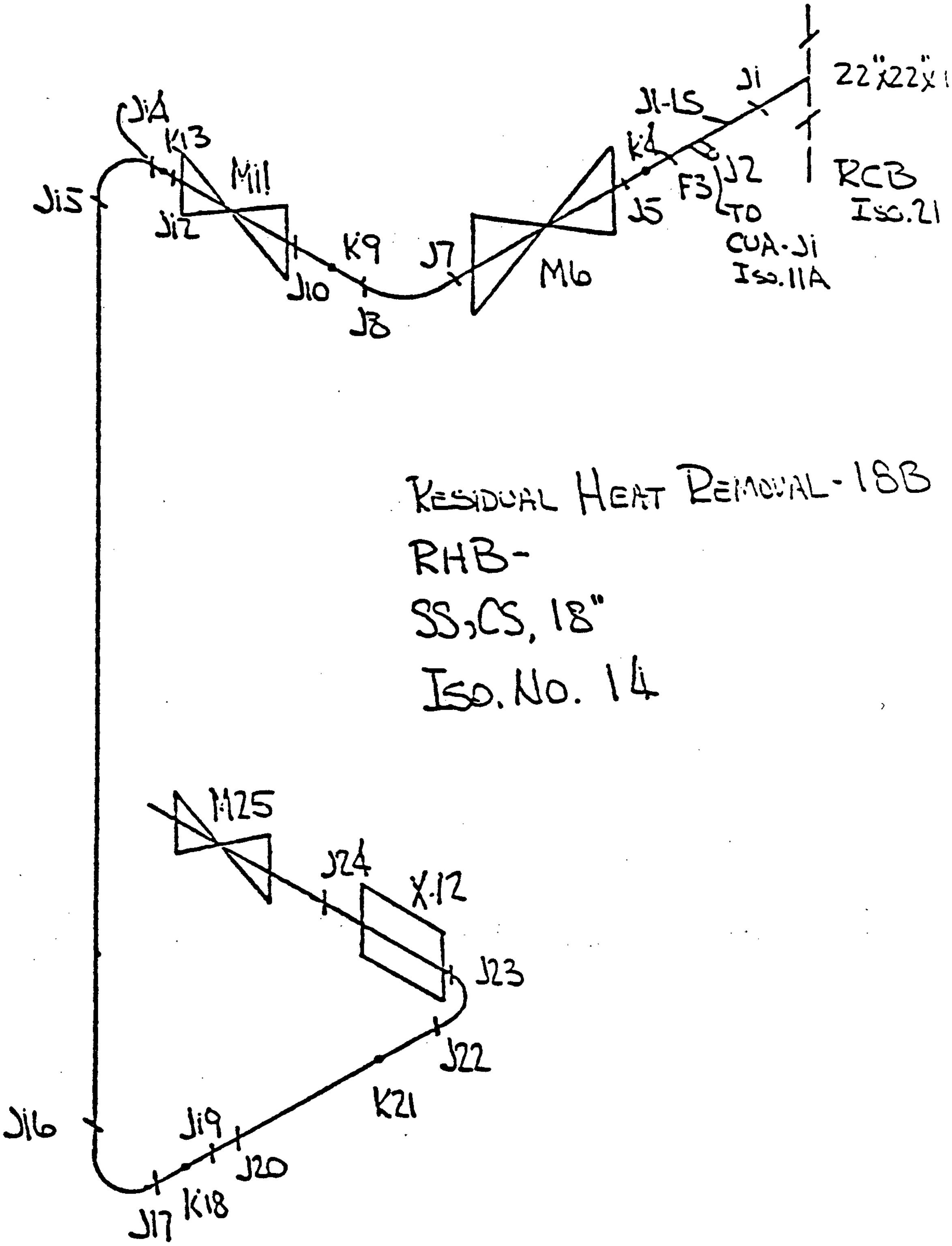
ECIRCULATION PUMP "A" &
ISCHARGE VALVE BY-PASS
CA- , RBA-
SS, 22", 4"
Iso. No. 19



RECIRCULATION PUMP "B" &
DISCHARGE VALVE BY-PASS
RCB- , RBB-
SS, 22", 4"
Iso. No. 21



RECIRCULATION MANIFOLD "B" & RISERS A,B,C,D
RMB-, RRA-, RRB- RRC-, RRD-,
SS, 16", 10"
ISO. NO. 22



RESIDUAL HEAT REMOVAL-18B

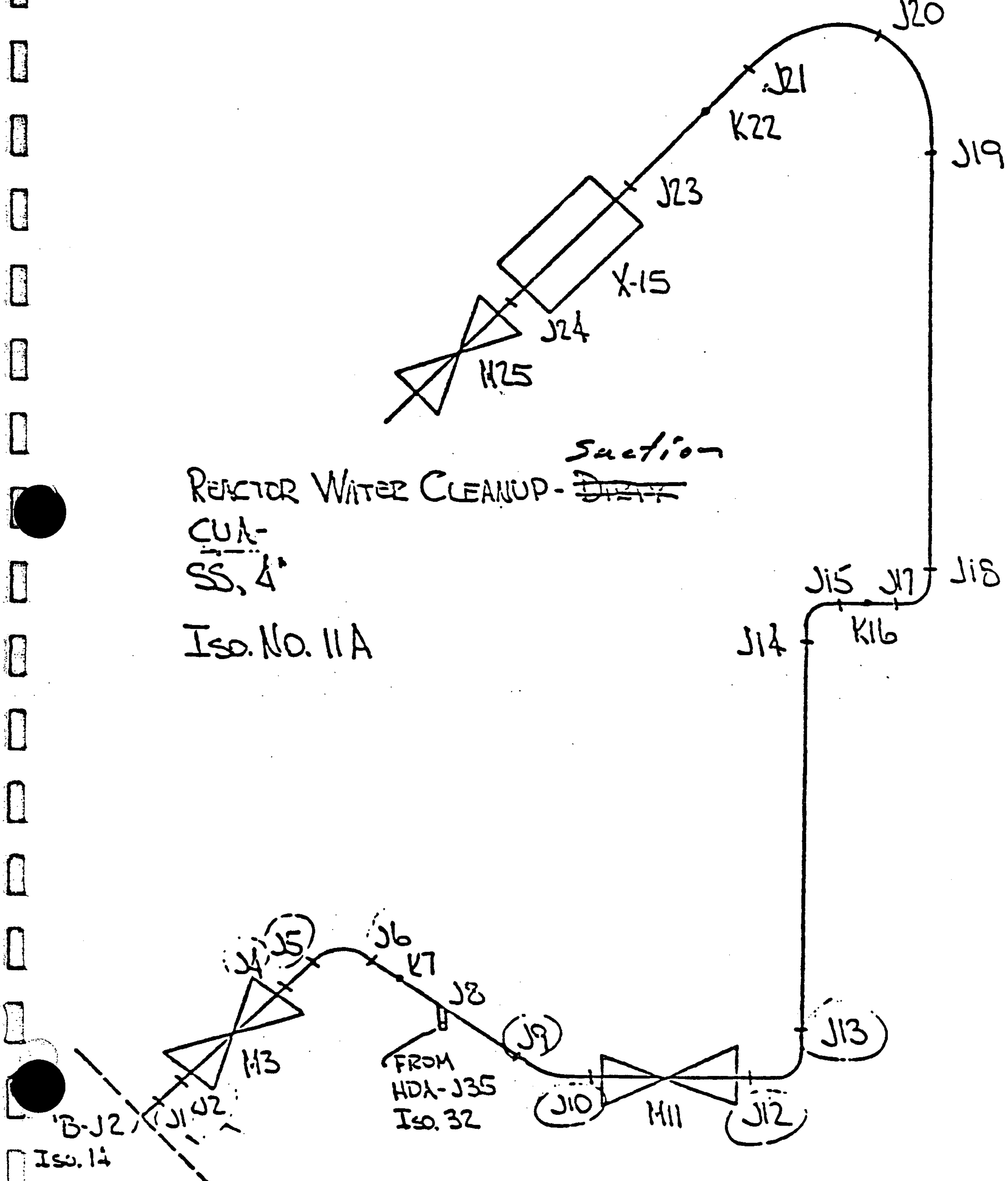
RHB-

SS, CS, 18"

ISO. NO. 14

REACTOR WATER CLEANUP - ~~DRAIN~~ *Suction*
CUA-
SS, 4"

Iso. No. 11A



ATTACHMENT 4

Summary of Recirculation System UT Results, 1981-1982

1981 - A total of 48 welds were examined with the following results:

A) 17 welds - no indications
B) 21 welds - geometry < 50% DAC
C) 5 welds - geometry 50% to 75% DAC
D) 4 welds - geometry > 75% DAC
E) *1 weld - Linear Indication

*Weld RRC-BJ4 had a linear indication ~ 3 1/4" long = 50% DAC. A decision was made to periodically monitor this weld.

1982 - A Total of 21 Welds Were Examined With The Following Results:

A) 8 Welds - Geometry < 50% DAC
B) 3 Welds - Geometry 50% to 75% DAC
C) 9 Welds - Geometry > 75% DAC
D) *1 Weld - Linear Indication

*Weld RRC-BJ4 was examined with identical results in 1981 and 1982.

ATTACHMENT 5

Iowa Electric Light and Power Company

June 30, 1981
LDR-81-225

LARRY D. ROOT
ASSISTANT VICE PRESIDENT
OF NUCLEAR DIVISION

RECEIVED
JUL 20 1981
I.E.L.P. Co.
Mech/Nuclear
Engineering

RECEIVED
JUL 8 1981
NUCLEAR LICENSES and FUELS

Mr. Harold Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Denton:

Enclosed herewith is Iowa Electric Light and Power Company's response to the requirements set forth in NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping".

This submittal is in response to the February 26, 1981 letter from Mr. Darrell Eisenhut concerning implementation of NUREG-0313, Rev 1. The proposed augmented inservice inspection and technical specification amendments to be accomplished on the schedule set forth in the enclosed response are deemed adequate to comply with the requirements of the NUREG.

Very truly yours,

Larry D. Root

Larry D. Root
Assistant Vice President
Nuclear Generation

LDR/RFS/mb
Attach.
cc: R. Salmon
D. Arnold
L. Liu
S. Tuthill
D. McGaughy
K. Meyer
D. Mineck
J. VanSickel
K. Eccleston (NRC)
NRC Resident Office
File A-107a, LC810226

Response Due

~~Root~~	Bolos	Loehrlein	Tepiy, D
~~McGaughy~~	Bechtel (AA)	Lewenstein	Van Middlesworth
~~Mineck~~	Bjorseth	Mick	~~Van Sickel~~
Ward	Blase	Nodean	Wilson
Meyer	Dye	Pelte	York
Youngs	Ellis	Pitner	Young
Rehrauer	Gucciardo	Salmon	
Bain (GE)	Hannen	Sheffel	
	Comm Cont #		
	NRC Master File#		
File(s) A-107a			

DUANE ARNOLD ENERGY CENTER
PROPOSED IMPLEMENTATION OF THE
REQUIREMENTS SET FORTH IN
NUREG-0313 REV 1
"TECHNICAL REPORT ON MATERIAL SELECTION
AND PROCESSING GUIDELINES FOR BWR
COOLANT PRESSURE BOUNDARY PIPING"

Presented below is a delineation of the requests set forth in the implementation letter for NUREG-0313, Rev 1, and a description of the proposed method to be employed by the Iowa Electric Light and Power Company to meet the requests.

Requirement:

Review all of the ASME Class 1 and 2 Pressure boundary piping, safe ends, and fitting material, including weld metal, at your facility to determine if it meets the material selection, testing and processing guidelines set forth in the enclosed report.

Response:

Our review of the RCS pressure boundary piping was completed in 1978. We refer to our submittals of December 30, 1977 (IE-77-2342) and March 15, 1978 (IE-78-386).

Requirement:

Identify to us any materials that do not meet these guidelines and propose appropriate changes to your Technical Specifications to incorporate the augmented inservice inspection requirements specified in Section IV of the enclosed report.

Response:

Attachment 1 identifies the material which does not meet the guidelines and defines our proposed augmented inservice inspection.

Requirement:

In the case of "service sensitive" lines you should also provide your plans and schedule for the replacement, to the extent practicable, of nonconforming materials with those that conform to the staff's guidelines.

Response:

Iowa Electric presently does not have any plans to replace the "service sensitive" lines. Contingency plans to cap or replace lines have been developed but will be implemented only if warranted by the results of the inservice inspections.

Requirement:

We request that if it is needed, you propose appropriate changes to your Technical Specifications to bring them into conformance with the enclosed report.

Response:

The model Technical Specifications have been reviewed and appropriate changes identified. A copy of the changes which Iowa Electric will propose is enclosed as Attachment 2. This proposed change will be submitted in a format consistent with the DAEC Technical Specifications on a schedule identified below.

Requirement:

You should propose a schedule to accomplish the above requested actions or a description, schedule and justification for alternative actions to accomplish the objectives of this program.

Response:

Iowa Electric proposes that the augmented inservice inspection program be implemented with the beginning of the next 40 month period of the current 120 month cycle. This period will begin at the end of the present cycle. The Technical Specification amendment proposed above, and included as Attachment 2, will be submitted in a manner which will support the proposed schedule.

Attachment 1

Identification of ASME Code Class 1 and 2 pressure boundary piping, safe ends, fitting material and weld material, and proposed alternate actions to accomplish the objectives of NUREG 0313 Rev. 1.

1. Conforming Material

All stainless steel safe ends and stainless steel safe end extensions are conforming material. All contain less than .035% carbon and were solution annealed. Inconel welds join the stainless steel safe ends to the nozzles. Class 1 pressure boundary piping except that identified in 2 and 3 are conforming, and all Class 2 piping is conforming.

2. Partial Non-Conformance but not Service Sensitive

The following systems are non conforming - non service sensitive in accordance with guidelines of NUREG 0313 Rev. 1.

a. Recirculation system except the bypass pipe.

b. RHR stainless steel transition spools to the recirculation system.

c. Liquid level control (Reactor Vessel).

d. Instrumentation piping (Reactor Vessel).

Stainless steel pipe and fittings in the above systems contain greater than 0.035% carbon, and the welds have not been solution annealed, therefore are non-conforming. All pipe and fittings have been solution annealed. Selection of welds for augmented in-service inspection on item "a" and "b" systems will be those most susceptible for IGSCC based on the stress rule index number. In-service inspection will be accelerated to an 80 month period. Because pipe in items "c" and "d" are small diameter, we propose to continue inspection in accordance with ASME Section XI but the inspection cycle will be completed in 80 months.

3. Partial Non-Conformance and Service Sensitive

The following do not conform to the criteria as stated in NUREG 0313 Rev. 1 and are considered to be service sensitive:

a. Recirculation system bypass.

b. Core spray spools that connect carbon steel pipe to stainless steel safe-end extensions at the RPV nozzles.

c. CRD Hydraulic return spool that connects carbon steel pipe to the RPV nozzle.

d. Reactor water cleanup systems.

The stainless steel pipe and fittings in the above systems contain greater than 0.035% carbon, and the welds have not been solution annealed. All pipe and fittings have been solution annealed. Augmented inservice inspection has been done on the above systems in accordance with the guidelines of NUREG 0313 Rev. 1.

Attachment 2

MODEL TECHNICAL SPECIFICATIONS - Licensee

APPLICABILITY

SURVEILLANCE REQUIREMENTS

4.0.1 Surveillance Requirements shall be met during the OPERATIONAL CONDITIONS or other conditions specified for individual Limiting Conditions for Operation unless otherwise stated in an individual Surveillance Requirements.

4.0.2 Each Surveillance Requirement shall be performed within the specified time interval with:

a. A maximum allowable extension not to exceed 25% of the surveillance interval, but

b. The combined time interval for any 3 consecutive surveillance intervals shall not exceed 3.25 times the specified surveillance interval.

4.0.3 Failure to perform a Surveillance Requirement within the specified time interval shall constitute a failure to meet the OPERABILITY requirements for a Limiting Condition for Operation. Exceptions to these requirements are stated in the individual Specificatons. Surveillance requirements do not have to be performed on inoperable equipment.

4.0.4 Entry into an OPERATIONAL CONDITION or other specified applicable condition shall not be made unless the Surveillance Requirement(s) associated with the Limiting Condition for Operation have been performed within the applicable surveillance interval or as otherwise specified.

4.0.5 Surveillance Requirements for inservice inspection and testing of ASME Code Class 1, 2, & 3 components shall be applicable as follows:

a. Inservice inspection of ASME Code Class 1, 2, and 3 components and inservice testing of ASME Code Class 1, 2, and 3 pumps and valves shall be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda as required by 10 CFR 50, Section 50.55a(g), except where specific written relief has been granted by the Commission pursuant to 10 CFR 50, Section 50.55a(g) (6) (i).

b. Surveillance intervals specified in Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda for the inservice inspection and testing activities required by the ASME Boiler and Pressure Vessel Code and applicable Addenda shall be applicable as follows in these Technical Specifications:

ASME Boiler and Pressure Vessel Code and applicable Addenda terminology for inservice inspection and testing activities	Required frequencies for performing inservice inspection and testing activities
Weekly	At least once per 7 days
Monthly	At least once per 31 days
Quarterly or every 3 months	At least once per 92 days
Semiannually or [illegible]y 6 months	At least once per 184 days
Every 9 [illegible]	At least once per 276 days

APPLICABILITY

SURVEILLANCE REQUIREMENTS (Continued)

c. The provisions of Specification 4.0.2 are applicable to the above required frequencies for performing inservice inspection and testing activities.

d. Performance of the above inservice inspection and testing activities shall be in addition to other specified Surveillance Requirements.

e. Nothing in the ASME Boiler and Pressure Vessel Code shall be construed to supersede the requirements of any Technical Specification.

4.6.6 All ASME Code Class 1, and 2 lines shall conform to the guidelines stated in the NUREG-0313, Rev. 1, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," July 1980, except for the following alternative actions:

a. Selection of welds for augmented in-service inspection in non-conforming non-service sensitive pipe in the recirculation system will be based on the stress rule index number and carbon content. Twenty-five percent of all welds that are most susceptible to IGSCC will be inspected in an 80 month cycle.

b. The recirculation system riser pipe will be classified non-conforming but not service sensitive and selection of welds for augmented in-service inspection will be as designated in "a" above.

c. Selection of welds for augmented in-service inspection in non-conforming non-service sensitive small instrumentation and liquid level control pipe will be in accordance with ASME Section XI but the inspection cycle will be completed in 80 months.

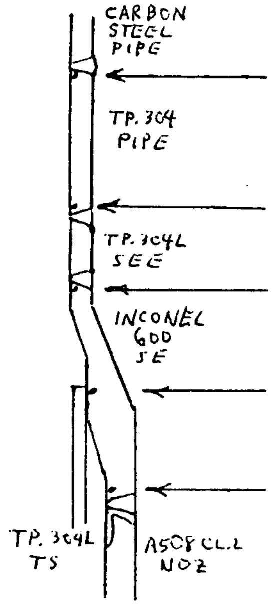
NG-82-2784
Dec. 21, 1982

ATTACHMENT 6

DAEC Core Spray Safe Ends
and
Adjacent Piping Stress Rule Index Numbers

nutech
San Jose, California

PROJECT: Duane Arnold Energy Center
OWNER: Iowa Electric Light and Power Company
CLIENT: Iowa Electric Light and Power Company
FILE NO. 25.1656.01[illegible]



LOCATION	P_m+P_b+Q	P_m+P_b	P_m	P_m+P_b+Q+F	R	STRESS RULE INDEX	REMARKS
①	17,721	5,459	—	29,722	36,000	1.15	(A)
	—	5,706	—	39,289	36,000	1.24	(B)
②	21,279	5,731	—	54,667	36,000	1.52	(C)
	—	4,911	—	42,747	36,000	1.31	(D)
③	28,703	20,211	13,175	47,620	42,000	1.51	(E)
	28,703	20,211	13,175	77,186	42,000	1.85	(E_1)
④	28,780	13,759	10,786	28,380	0	0.65	(F)
⑤	35,744	13,617	8,589	63,483	39,100	1.50	(G)

REMARKS:

(A) VALUES OF P_m+P_b, Q, F FROM BECHTEL STRESS REPORT (APP. D, p. D-6, D-7).
(B) FROM NUTECH CALCULATIONS (APP. A), BASED ON BECHTEL FORCES AND MOMENTS (APP. D, p. D-8, D-9).
(C),(D) SAME AS (A) AND (B), USING STRESS INDICES FOR AS-WELDED TRANSITION JOINT.
(E) VALUES OF P_m, P_m+P_b, P_m+P_b+Q FROM CB&I STRESS REPORT (APP. C, p. C-5, C-3, C-8, RESPECTIVELY). NB-3680 STRESS INDICES FOR BUTT WELDING REDUCERS WITH FLUSH WELDS WERE USED (SEE APP. A).
(E_1) SAME AS (E), EXCEPT USE NB-3680 STRESS INDICES FOR AS-WELDED REDUCER BUTT WELD.
(F) CREVICE LOCATION - NO WELD (CLEARANCE FIT OF 0.004" MAX.).
(G) SAME AS (E) - FLUSH.

TABLE - 1

SUMMARY OF STRESS RULE INDEX CALCULATIONS FOR DAEC CORE SPRAY SAFE END AND ADJACENT PIPING.

REVISION	PREPARED BY / DATE	CHECKED BY / DATE
0	JFC 10-27-82	[initials] 11-4-82

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