Attachment to
NG-85-1901

DUANE ARNOLD ENERGY CENTER

INSPECTION AND REPAIR PLANS FOR RECIRCULATION PIPING WELDS DURING 1985 REFUELING OUTAGE

MAY 1985

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INTRODUCTION

During the 1985 refueling outage, a comprehensive program addressing Intergranular Stress Corrosion Cracking (IGSCC) was implemented at the DAEC. This program included a thorough inspection of welds susceptible to IGSCC and Induction Heating Stress Improvement (IHSI) of welds in the Recirculation System.

As a result of the ultrasonic inspections performed, several stainless steel welds in the Recirculation System were found to have code-reportable indications. The following is submitted by Iowa Electric Light and Power Company to provide information on the results of the inspection program, qualifications of personnel and inspection procedures, repair plans, and future plans.

INSPECTION

Inspection Program

Generic Letter 84-11 and IE Bulletins 82-03 and 83-02 established guidelines for weld selection for examination, reinspection requirements, and qualification requirements for examiners and procedures. The inspection program for the DAEC as described in our June 18, 1984 response to GL 84-11, and the repair program described in this response, meet or exceed the intent of the generic letter and bulletins.

The In-Service Inspection (ISI) package assembled for the 1985 outage included plans for non-destructive examination (NDE) of all recirculation system circumferential butt welds. A 100% pre-IHSI UT survey of all welds to be IHSI treated and a 100% post-IHSI exam of all welds which were IHSI treated has been completed.

In the past Iowa Electric has selected welds to be examined based upon the following: 1) Most highly susceptible welds based on Stress Rule Index; 2) Industry experience pointing to welds more susceptible to Intergranular Stress Corrosion Cracking (IGSCC); 3) Construction and fabrication knowledge which would indicate welds of high stress, high carbon content, unusual fit-up geometry, or other problems encountered during construction.

For the current 1985 outage it was decided to perform a UT survey prior to IHSI treatment. This survey was to determine if unacceptable indications existed which may preclude IHSI of particular welds. The survey utilized the same qualified procedure, equipment and personnel (with the exception of a Level III examiner) that were used in the post-IHSI exam. The survey was intended to be informational, and as such, a Level III review was not required.

The post-IHSI UT was a thorough ASME examination evaluated by a Level III examiner for the purpose of Section XI ISI and was performed to serve as a basis for future operation and UT evaluations.

<u>Qualifications of Personnel, Procedures, and Equipment</u>

IE Bulletin 83-02 requires that personnel who supervise, perform examinations or record test data, participate in a performance demonstration test which may be witnessed by the NRC. In addition, the personnel must have the proper documented training in IGSCC inspection, using cracked thick-wall specimens, and must be under the direct supervision of level II or III UT examiners who have successfully completed the performance demonstration test.

During this outage, Iowa Electric contracted NDE examination services through Lambert, MacGill, Thomas, Inc. (LMT). Table 1 provides the qualifications of LMT personnel involved in DAEC NDE inspection and IGSCC detection. As illustrated in this table, all level II and level III UT personnel have completed the IGSCC qualification course, which was witnessed by an NRC representative, and are qualified Level II in IGSCC detection.

Level I personnel were qualified by passing a calibration block test. This permits the level I personnel to assist the Level II or III personnel. This test consisted of the Level I performing an acceptable calibration utilizing LMT exam procedure UT 10 Rev. 11.

Bulletin 83-02 also required that procedures and equipment be validated capable of detecting IGSCC. LMT's procedures and equipment were validated capable of detecting IGSCC during EPRI performance demonstration tests. LMT uses the same equipment and procedures at the DAEC that were used at EPRI.

IHSI Program

The Induction Heating Stress Improvement (IHSI) Program was scheduled for this current refueling outage to include the 107 recirculation system welds listed in Table 2. A pre-IHSI ultrasonic weld survey was performed on each weld prior to applying the IHSI treatment. This was followed with a post-IHSI ultrasonic examination of each weld treated.

Indications evaluated as possible IGSCC were detected in recirculation system loop "B" welds RRD-J7 and RRD-J4 prior to applying the IHSI treatment. These welds were removed from the scope of IHSI until repairs could be accomplished. Due to the close proximity of the RRD-J4A weld to the RRD-J4 weld, RRD-J4A was also excluded from the IHSI treatment.

Nutech was contracted to perform the IHSI application. Their scope of work included the design and procurement of the heating coils, technical direction of local craft individuals for the installation and removal of the thermocouples and heating coils, development of control parameters, and control of the power supply operation.

Indoctrination, training and qualification of personnel involved in the listed activities were accomplished on a mock-up weld configuration prior to these personnel being assigned to work on the recirculation system piping. Training and qualification records have been retained on those individuals involved in the IHSI application for the following areas: 1) power supply operation, 2) coil and thermocouple placement, 3) low energy capacitive discharge welding (for thermocouple attachment), and 4) auditing.

Nutech developed the IHSI control parameters for the DAEC based on an evaluation of data collected on the following parameters: 1) pipe diameter and variation, 2) wall thickness and variation, 3) contours, especially at valve and pump bodies and any mismatched joint, and 4) attachments such as lugs, weldolets, etc. The IHSI control parameters are described in Table 3.

Inspection Results

As a result of inspections performed prior to and following IHSI, eleven indications were found. A tabular summary of these results is included in Table 4. Locations of the indications are identified in the figures showing loops A and B of the recirculation system.

The following is a summary description of indications found:

1) Weld No. RRA-J4; Elbow to pipe weld in "A" riser.

   Indication: No code-reportable indications were detected by UT before IHSI. After IHSI, a small leak was detected at a location 3/4" from weld centerline and 2-1/2" CCW from Top Dead Center (TDC) of the pipe on the elbow side. Subsequently, an axial linear indication was detected at the leaking area and extended from the outer surface to more than 50% of wall. The indication could not be tracked to the inner surface.

2) Weld No. RRA-J4A; Pipe to pipe weld in "A" riser.

   Indication: 30% through-wall circumferential linear indication 9" long starting from a point 24-1/2" from TDC in the CW direction. The indication is at the root of the weld on the upstream side. Indications detected in pre-service baseline examination and examination prior to IHSI were evaluated as root geometry.

3) Weld No. RRB-J4A; Pipe to pipe weld in "B" riser.

   Indication: 25% through-wall circumferential linear indication 3-1/4" long starting from a point 5-1/4" from TDC in a CW direction. The indication is at the root of the weld on the upstream side. The indications detected in pre-service baseline and pre-IHSI examinations were evaluated to be geometric reflectors.

4) Weld No. RRD-J4A: Pipe to pipe weld in "D" riser.

Indication: 40% through-wall circumferential indication 6-1/2" long from a point 1" CCW from TDC to 5-1/2" CW from TDC. The pre-service baseline was evaluated as a geometric reflector.

5) Weld No. RRD-J4: Elbow to pipe weld in "D" riser.

Indications: Two axial linear indications and one circumferential linear indication were detected in a cluster at 1" from weld centerline and 1/2" from TDC on the pipe side. The axial indications appear to be 60% through-wall and the circumferential appeared to be about 15% through-wall.

6) Weld No. RRE-J4A: Pipe to pipe weld in "E" riser.

Indication: 60% through-wall circumferential linear indication 3-3/8" long starting from a point 18-5/8" from TDC in the CCW direction. The indication is near the root on the upstream side of the weld. Indications detected prior to IHSI were evaluated as geometric reflectors.

7) Weld No. RRF-J4A: Pipe to pipe weld in "F" riser.

Indication: 85% through-wall circumferential linear indication 2" long from a point 14" from TDC in the CW direction. The indication appears to follow the fusion line of the weld on the upstream side of the weld. Prior to IHSI, the indication was evaluated as a geometric reflector.

8) Weld No. RRG-J4A: Pipe to pipe weld in "G" riser.

Indication: 75% through-wall circumferential linear indication extending 8" from a point 25-1/2" from TDC in the CW direction. The indication was near the root of the weld and on the upstream side. A similar indication 2-1/2" long from a point 18" from TDC in the CW direction was detected. The indications were near the root of the weld on the upstream side. All indications detected prior to IHSI were evaluated as geometric reflectors.

9) Weld No. RRH-J4A: Pipe to pipe weld in "H" riser.

Indication: 70% through-wall circumferential linear indication extending 2-1/8" from a point 19-7/8" from TDC in the CW direction. Reflectors noted in examinations prior to IHSI were evaluated as geometric.

10) Weld No. RHB-J1: RHR branch (18") connection to recirculation system tee.

Indication: A small leak approximately 5" CW from TDC on the tee side of the weld was detected. The weld was examined both before and after IHSI from the pipe side and no relevant indications were detected at the leak location. Because of the configuration of the tee, the joint could not be examined from the tee side of the weld.

11) Weld No. RRD-J7: Transition piece to pipe at the branch connection for the "D" riser.

Indication: An indication was evaluated as linear and axially oriented. The indication was determined to be approximately 25% through-wall and located approximately 13-3/4" CW from 0° (0° is point on pipe in-line with the outer radius of the riser elbow). Additional ultrasonic examinations indicate that a subsurface laminar condition exists. These indications may be attributed to non-metallic inclusions or similar pipe processing discontinuities. The indication is not considered to be associated with IGSCC. Planar indications were found in an area 4" wide, circumferentially running from near the fusion line 5" downstream.

REPAIR PLANS

Weld Overlay Repair

General Electric has been contracted to perform the weld overlay design and application of the process. Overlays are designed and evaluated in accordance with the requirements of the ASME Code, Section XI, 1983 Edition through Winter 1984 Addenda supplemented by the requirements of GL 84-11. The designs applied for circumferential indications are full structural Type 1 overlays that satisfy ASME Code design and safety margins, regardless of crack length or through-wall depth. The overlays applied are considered suitable for more than one refueling cycle of operation, but are presently planned for a single refueling cycle. Longer term operation may be considered as discussed in the section of this report which addresses future plans.

The weld overlays are designed and applied to provide a weld overlay deposit that is highly resistant to IGSCC (including the first layer). Additional design margin is provided by not taking credit for the first overlay layer for meeting design requirements and a minimum of two layers are applied following the first layer. Credit will be taken for the first overlay layer on the RRD-J7 weld subject to the following conditions: 1) the deposition of the first layer will be videotaped and the weld supervisor will review this video looking for any indication of a steam blowout; 2) a visual inspection will be performed to look specifically for any pockmarks or discolorations indicative of a steam blowout; 3) a PT exam will be performed; and 4) the average delta ferrite will be verified to be at least 8 FN. Satisfactory completion of the first overlay layer followed by a minimum of two additional layers will result in an overlay thickness sufficient to qualify as a full structural Type 1 overlay. These design requirements comply fully with the recommendations in Generic Letter 84-11.

To provide additional design margin for longer term operation, the overlays applied to welds with only axial indications are designed to provide full structural margin for circumferential cracking.

The overlay design for those risers with an indication only in the J4A weld has sufficient length to qualify as a Type 1, full structural overlay for both the J4A and J4 welds. (See recirculation loop figures.) The proximity of these two welds is such that any overlay design for J4A alone would inhibit future inspectability of J4. To optimize inspectability, the overlay is extended beyond J4 to accommodate ultrasonic examination of both J4A and J4 through the overlay material.

The welding material for the weld overlay is Type ER-308L. The material conforms to ASME Code Section III requirements (NB2400). The welding material composition and application is controlled by General Electric to produce a low carbon, high ferrite overlay deposit that is highly resistant to IGSCC.

The weld overlays will be applied using remote automatic Gas Tungsten Arc Welding (GTAW) with a closed circuit television monitoring system throughout the process. The welding application will be performed under an approved repair program in accordance with ASME Code Section XI, 1974 Edition through the Summer 1975 Addenda. Fabrication and installation requirements for overlays will be in accordance with ASME Code Section III, 1980 Edition through Summer 1982 Addenda. Non-destructive examination and pressure testing requirements will comply with ASME Code Section XI, 1974 Edition through Summer 1975 Addenda.

The weld overlay process will be preceded by a thorough review of the post-IHSI ultrasonic test results. Overlay examinations will start with a Liquid Penetrant (PT) examination of the surfaces to be overlayed. Any through-wall leaking conditions will be evaluated and locally seal weld repaired using General Electric approved and qualified procedures. After the first overlay layer is applied, a PT examination and delta ferrite check are performed. The remaining overlay layers are applied until the final thickness is obtained. The final overlay surface is PT examined, and is then volumetrically examined by UT in accordance with ASME Code requirements for structural weld material. After the results of the final UT are found to be acceptable, a hydrostatic test will be conducted in conjunction with the 10-year recirculation system hydrostatic test (ref. ASME Section XI, IWB 5000).

Fracture Mechanics Flaw Evaluation is not currently planned since all identified indications will be repaired during this present schedule. However, if additional indications present themselves as likely candidates for Fracture Mechanics Flaw Evaluation, then the following criteria will be applied to performing that analysis: SECY-83-267c, IWB-3640, NUREG 1061 and Generic Letter 84-11.

ALARA

Established plant procedures are being used to control radiation exposure for the pipe repair project. Because of the substantial amount of work in radiation areas, several measures are being taken to reduce the man-Rem exposure. Mock-up training is being used extensively to qualify techniques and facilitate testing of alternatives. The areas are shielded using framework supported lead blankets as much as practicable. Whenever possible, large diameter piping is filled with water as additional shielding. Special training using videotapes will be used to educate high exposure workers (such as PT inspectors) in how to "work smart." Automated welding equipment is used to perform the weld overlays. This equipment allows remote completion of all welding after equipment installation and repair of any through-wall leakage.

Fully established practices are to be followed for the UT inspection of the weld overlays. These practices include careful control of stay time and extensive use of lead blankets.

A man-Rem evaluation will be performed for each task before work begins. The estimated man-Rem exposure is found in Table 5. Initial estimates for the project are based on an estimate of 18,000 manhours. This estimate is subject to revision based on change of work scope and additional refinement of manhour estimates.

FUTURE PLANS

It has not yet been determined whether modifications or replacement of recirculation piping will be necessary during future refueling outages. The next refueling outage (Cycle 8/9) is scheduled to begin in February of 1987. Since the repairs being made during this outage consist of full structural Type 1 overlays, operation beyond one cycle may be possible depending on "state-of-the-art" advances in examination capability between now and the next refueling outage.

Plans are being made to replace the affected piping during a future refueling outage, if necessary. Replacement materials will be made of stainless steel resistant to IGSCC and installation will be followed by IHSI or another IGSCC mitigation measure. A reinspection program to augment the normal ISI program and address the weld overlays will be developed and submitted to the NRC prior to the next refueling outage.

SUMMARY AND CONCLUSIONS

Inspection of the DAEC Recirculation System performed during the 1985 refueling outage meets or exceeds the intent of NRC Generic Letter 84-11 and I&E Bulletins 82-03 and 83-02. The inspection included a complete survey of Recirculation System welds, IHSI of 104 of the 107 welds, and 100% NDE reinspection of all welds on which IHSI was performed. NDE testing was performed by qualified personnel in accordance with procedures which were validated to be capable of detecting IGSCC. Ten welds in the recirculation system were observed to have reportable IGSCC-like indications. One weld (RRD-J7) was determined to have an indication not associated with IGSCC.

Flaw evaluations and repairs will be performed which meet or exceed the criteria of NRC GL 84-11. Full structural Type 1 weld overlay repair will be performed on all indications. Leakage detection provided at DAEC as described in response to NRC GL 84-11 provides a high degree of assurance that any through-wall leakage would be detected at an early stage.

Iowa Electric concludes that the inspection and repair program being conducted during the DAEC 1985 refueling outage provides an adequate basis for returning to power operation.

TABLE 1

LMT PERSONNEL QUALIFICATIONS

Don Harvey - Certifications - ANST - Level III UT, PT, MT

ANST - Level I ET

EPRI - Level III VT-1, VT-2, VT-3 and VT-4

Additional Training - EPRI - 40 hour training and qualification for IGSCC detection (Level II) July 1983

EPRI - 40 hour UT operator training and certified for planar flaw mapping. July 1983

Jessie French - Certifications - LMT Level II UT, PT, VT

Additional Training - EPRI - 40 hour training and qualification for IGSCC detection (Level II) Sept. 83

Kevin Hall - Certifications - LMT Level II UT, Level I VT-2

Additional Training - EPRI - 40 hour training and qualification for IGSCC detection (Level II) Feb. 85

Charles Pattillo - Certifications - LMT Level II UT, MT, PT and VT-1

Additional Training - EPRI - 40 hour training and qualification for IGSCC detection (Level II) Feb. 85

David Richey - Certifications - LMT Level II UT, PT and MT

Additional Training - EPRI - 40 hour training and qualification for IGSCC certification (Level II) Feb. 85

TABLE 2

WELDS SCHEDULED FOR IHSI DURING 1985 OUTAGE

Reactor Recirculation System Loop "A"

Weld Number	Weld Type
RCA-J3	22" Pipe - Safe End
RCA-J4	22" Pipe - Elbow
RCA-J5	22" Pipe - Elbow
RCA-J6	22" Pipe - Pipe
RCA-J8	22" Pipe - Pipe
RCA-J12	22" Pipe - Elbow
RCA-J13	22" Elbow - Valve
RCA-J15	22" Pipe - Valve
RCA-J21	22" Pipe - Elbow
RCA-J22	22" Elbow - Pump
RCA-J24	22" Pipe - Pump
RCA-J28	22" Pipe - Valve
RCA-J30	22" Elbow - Valve
RCA-J32	22" Pipe - Elbow
RCA-J38	22" Pipe - Pipe
RCA-J41	22" Pipe - Tee
RCA-J43	22" Tee - Cross
RMA-J1	16" Pipe - End Cap
RMA-J2	10" Manifold-Transition
RMA-J4	10" Manifold-Transition
RMA-J5	16" Pipe - Cross
RMA-J6	22" Pipe - End Cap
RMA-J7	16" Pipe - Cross
RMA-J8	10" Manifold-Transition
RMA-J10	10" Manifold-Transition
RMA-J11	16" Pipe - End Cap
RRE-F2A	10" Pipe - Safe End
RRE-J3	10" Pipe - Pipe
RRE-J4A	10" Pipe - Pipe
RRE-J4	10" Pipe - Elbow
RRE-J5	10" Pipe - Elbow
RRE-J7	10" Transition-Pipe
RRF-F2A	10" Pipe - Safe End
RRF-J3	10" Pipe - Pipe
RRF-J4A	10" Pipe - Pipe
RRF-J4	10" Pipe - Elbow
RRF-J5	10" Pipe - Elbow
RRF-J7	10" Transition-Pipe
RRG-F2A	10" Pipe - Safe End
RRG-J3	10" Pipe - Pipe
RRG-J4A	10" Pipe - Pipe
RRG-J4	10" Pipe - Elbow
RRG-J5	10" Pipe - Elbow
RRG-J7	10" Transition-Pipe
RRH-F2A	10" Pipe - Safe End
RRH-J3	10" Pipe - Pipe
RRH-J4A	10" Pipe - Pipe
RRH-J4	10" Pipe - Elbow
RRH-J5	10" Pipe - Elbow
RRH-J7	10" Transition-Pipe
RHC-J1	20" Pipe - Tee
RHC-F2	20" Pipe - Pipe

Reactor Recirculation System Loop "B"

Weld Number	Weld Type
RRB-J3	22" Pipe - Safe End
RRB-J4	22" Pipe - Elbow
RCB-J5	22" Pipe - Elbow
RCB-J6	22" Pipe - Tee
RCB-J7	22" Pipe - Tee
RCB-J9	22" Pipe - Pipe
RCB-J15	22" Pipe - Elbow
RCB-J16	22" Elbow - Valve
RCB-J18	22" Pipe - Valve
RCB-J24	22" Pipe - Elbow
RCB-J25	22" Elbow - Pump
RCB-J27	22" Pipe - Pump
RCB-J31	22" Pipe - Valve
RCB-J33	22" Elbow - Valve
RCB-J35	22" Pipe - Elbow
RCB-J41	22" Pipe - Pipe
RCB-J44	22" Pipe - Tee
RCB-J46	22" Tee - Cross
RMB-J1	16" Pipe - End Cap
RMB-J2	10" Manifold-Transition
RMB-J5	10" Manifold-Transition
RMB-J6	16" Pipe - Cross
RMB-J7	22" Cross - End Cap
RMB-J8	16" Pipe - Cross
RMB-J9	10" Manifold-Transition
RMB-J11	10" Manifold-Transition
RMB-J12	16" Pipe - End Cap
RRA-F2A	10" Pipe - Safe End
RRA-J3	10" Pipe - Pipe
RRA-J4A	10" Pipe - Pipe
RRA-J4	10" Pipe - Elbow
RRA-J5	10" Pipe - Elbow
RRA-J7	10" Transition-Pipe
RRB-F2A	10" Pipe - Safe End
RRB-J3	10" Pipe - Pipe
RRB-J4A	10" Pipe - Pipe
RRB-J4	10" Pipe - Elbow
RRB-J5	10" Pipe - Elbow
RRB-J7	10" Transition-Pipe
RRC-F2A	10" Pipe - Safe End
RRC-J3	10" Pipe - Pipe
RRC-J4A	10" Pipe - Pipe
RRC-J4	10" Pipe - Elbow
RRC-J5	10" Pipe - Elbow
RRC-J7	10" Transition-Pipe
RRD-F2A	10" Pipe - Safe End
RRD-J3	10" Pipe - Pipe
*RRD-J4A	10" Pipe - Pipe
*RRD-J4	10" Pipe - Elbow
RRD-J5	10" Pipe - Elbow
*RRD-J7	10" Transition-Pipe
RHB-J1	18" Pipe - Tee
RHB-F3	18" Pipe - Pipe
RHD-J1	20" Pipe - Tee
RHD-F2	20" Pipe - Pipe

*IHSI not performed.

TABLE 3

SUMMARY OF IHSI CONTROL PARAMETERS

Parameter	Value
Maximum Pipe Wall Outer Surface Temperature	1067°F (575°C)
Minimum Through-Wall Temperature Differential (ΔT)	495°F (275°C)
Minimum Width of Zone Heated to (ΔT) Minimum	$1.5 \sqrt{RT}$ R = Mean Pipe Radius T = Pipe Wall Thickness
Minimum Distance From Weld Center to Boundary of Zone Heated to ΔT Minimum	0.6 inch (15mm) or T/2 (whichever is larger)
Heating Duration (Minimum)	$t \geq 0.7\ T^2/a$ T = Pipe Wall Thickness a = Thermal Diffusivity
Frequency of Power Supply	3 to 4 ($\pm$10%) KHz
Minimum Induction Coil Length	$3 \sqrt{RT}$ R = Mean Pipe Radius T = Pipe Wall Thickness
Requested Nominal Water Velocity*	4.9 ft/sec
Requested Nominal Cooling Water Temperature*	104°F (40°C)

*Cooling water conditions which meet these values will assist in achieving the through-wall temperature differential, but these values are not essential control parameters.

TABLE 4

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INDICATIONS IN PIPING SUSCEPTIBLE TO IGSCC

Weld No.	Pipe Size (in.)	Identified During	Orientation	Length (in.)	Calculated Through-Wall Depth (%)
RRA-J4	10	Visual Leakage Post-IHSI	Axial	--	100%*
RRA-J4A	10	Post-IHSI UT	Circum	9"	30%
RRB-J4A	10	Post-IHSI UT	Circum	3-1/4"	25%
RRD-J4A	10	Pre-IHSI UT	Circum	6-1/2"	40%
**RRD-J4	10	Pre-IHSI UT	Axial Axial Circum	7/8" 7/8" 1/4"	60% 60% 15%
RRD-J7	10	Pre-IHSI UT	Axial Lamination	1/2" --	25% --
RRE-J4A	10	Post-IHSI UT	Circum	3-3/8"	60%
RRF-J4A	10	Post-IHSI UT	Circum	2"	85%
RRG-J4A	10	Post-IHSI UT	Circum	8"	75%
RRH-J4A	10	Post-IHSI UT	Circum	2-1/8"	70%
***RHB-J1	18	Visual Leakage Post-IHSI	Presumed Axial	--	100%*

*100% based on visual leakage.

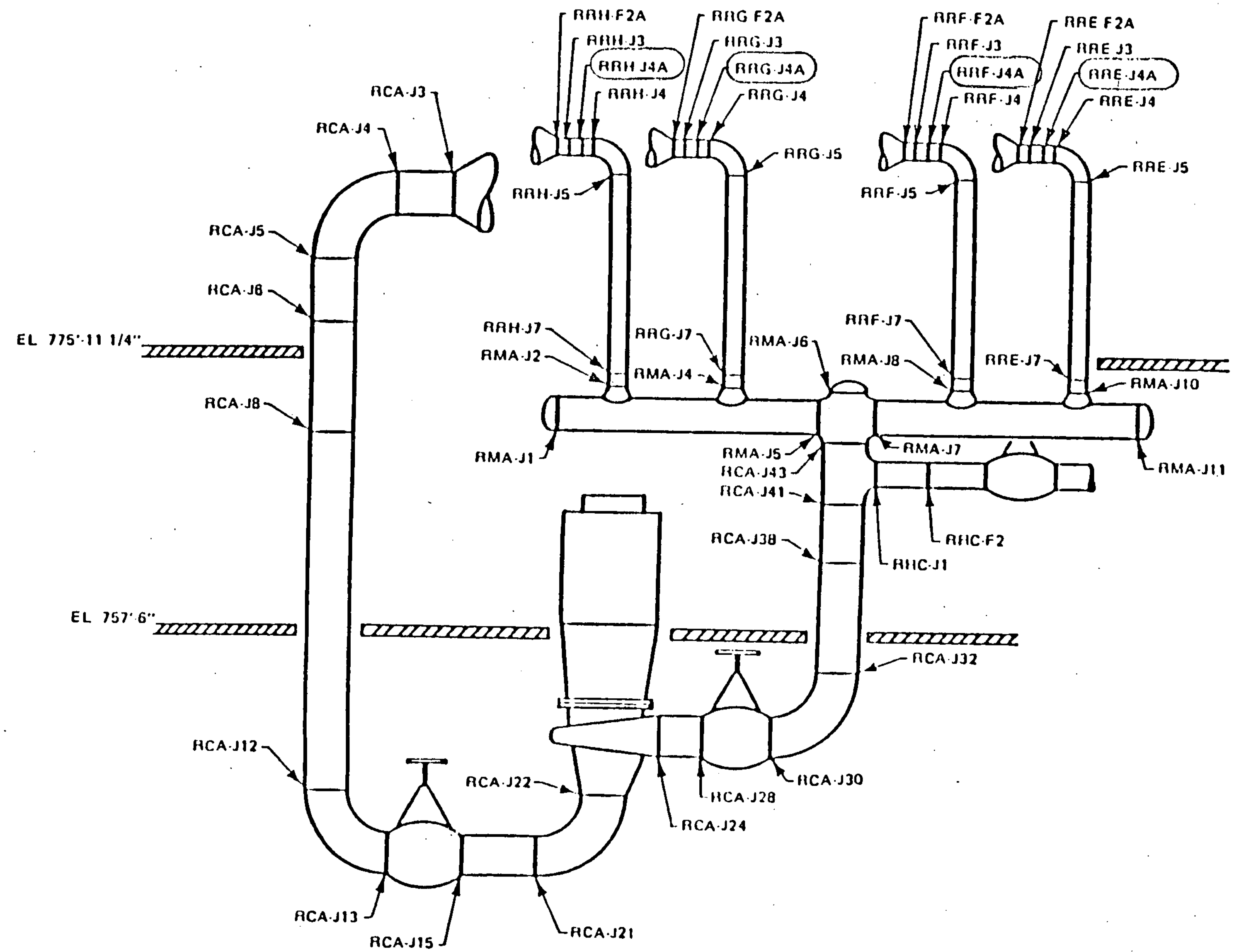
**Three indications all in close proximity.

***Note: Ultrasonic Testing is restricted by physical constraints.

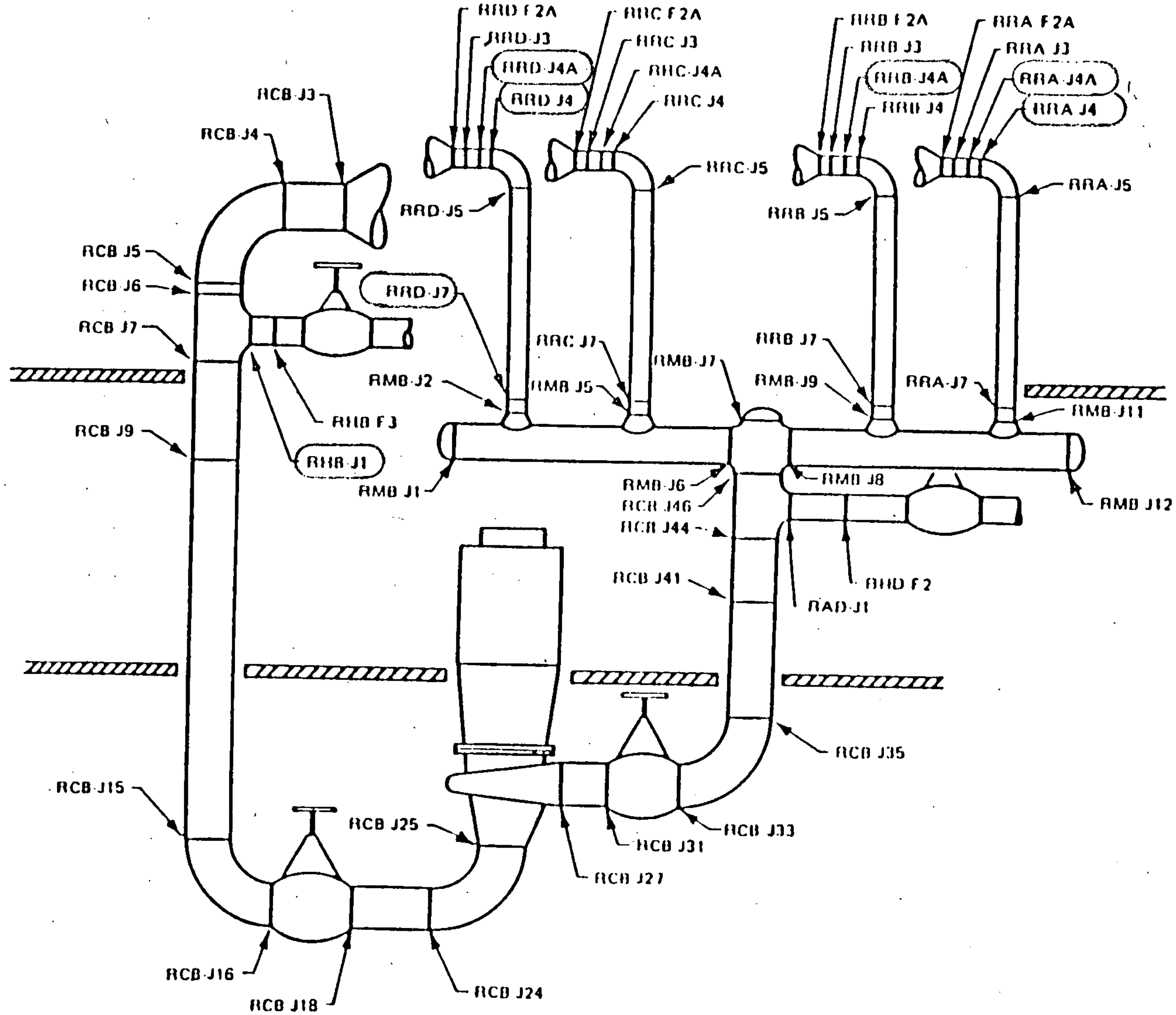
TABLE 5

MAN-REM ESTIMATE FOR RECIRCULATION SYSTEM REPAIR

Drywell Shielding	25 man-Rem
Inspections	64 man-Rem
Overlays	31 man-Rem
Labor Support (Including: Electrical, Pipefitter, Cleaning, Carpenter)	93 man-Rem
Supervision and HP Support	21 man-Rem
Total	234 man-Rem



REACTOR RECIRCULATION SYSTEM
LOOP A – DUANE ARNOLD ENERGY CENTER



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