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Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Alternate Code Repair for the ANO-1 Hot Leg Level Nozzle RC-1071/1072

Gentlemen:

On February 15, 2000, while shutdown to perform repairs on the anti-rotation device for the D reactor coolant pump on Arkansas Nuclear One, Unit 1 (ANO-1), a boron buildup was discovered on the insulation in the vicinity of the "A" reactor coolant system (RCS) Hot Leg Level nozzle associated with root valves RC-1063/1064. This nozzle is one of seven similarly designed nozzles, which were installed in 1986 as part of the hot leg level monitoring system. Upon removal of the insulation it was apparent that an RCS leak had occurred at the base of the nozzle. Insulation was also removed from around the remaining six potentially susceptible nozzles for both the "A" and "B" hot legs. Inspections of these nozzles revealed similar boron buildup on five of the nozzles. Since the unit was shutdown, there was no active leakage present. Further investigation indicated that the leakage was occurring at the structural weld at the base of the nozzles where they attach to the hot leg. These nozzles are Inconel-600 and the welds are Inco-182. An eighth nozzle installed on the decay heat line (also installed in 1986 for the hot leg level monitoring system) is of a stainless steel weld design.

Repair packages in accordance with Section XI of the ASME Code have been developed to repair six of the seven nozzles. However, one nozzle associated with root valves RC-1071/1072 cannot be repaired in accordance with existing ASME Section XI Code repair techniques since the nozzle is on the under side of the hot leg at elevation 368 feet, 5 inches which is below mid loop water level. An ASME Section XI Code repair of the nozzle will cause undo hardship by requiring a full core offload to reduce water level whereby incurring a significant delay in the restart of ANO-1.

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Entergy is proposing an alternate repair, which consists of a full structural weld overlay extending from the nozzle to the base metal of the RCS hot leg. The alternative repair will meet the ANO-1 ASME Section III design requirements as described in the attached Request No. 00-1-001, Rev. 0. The repair will remain in-service until the next ANO-1 refueling outage, 1R16, scheduled for the spring of 2001 at which time an ASME Code repair will be performed.

Therefore, in accordance with 10CFR50.55a(a)(3)(i) and (ii), Entergy is requesting NRC staff approval of an alternate repair for the hot leg nozzle associated with RC-1071/1072. This request is based on the proposed modification providing an acceptable level of quality and safety and full ASME Code repair in accordance with Section XI would result in undue hardship and unusual difficulty.

Please contact me if you have any further questions on this matter.

Very truly yours,

Jimmy D. Vandergrift
Director, Nuclear Safety Assurance

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Attachments

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Attachment to
1CAN020006

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE – UNIT 1
3rd TEN YEAR INTERVAL
REQUEST NO. 00-1-001, Revision 0

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE – UNIT 1
3 rd TEN YEAR INTERVAL
REQUEST NO. 00-1-001, Revision 0

I. COMPONENT IDENTIFICATION

Code Class:	1
Description:	Reactor Coolant System Instrument Tap located on the "B" Loop Hot Leg at Elevation 368'5".
Component Number:	Root Valves RC-1071 and 1072

References:

1. ASME Section XI, 1992 Edition with portions of the 1993 Addenda as listed in the ISI program.
2. Arkansas Nuclear One, Unit 1 Safety Analysis Report, Paragraph 4.1.3.2.
3. ANSI B31.7, "Code for Pressure Piping, Nuclear Power Piping, Dated February 1968.
4. ASME Section III, Subsection NB, 1989 Edition.
5. FTI Calculation 32-5007242-00
6. BAW Topical 10046 Rev.2
7. ASME Section III, Subsection NB, 1980 Edition, Through and including the Winter 1981 Addenda
8. FTI Document 51-5007187-00, "Corrosion Evaluation"

II. REQUIREMENTS

In accordance with IWA-5250, sources of leakage are to be located and if it does not originate from a buried component or a mechanical connection, the source of leakage is to be repaired or replaced in accordance with IWA-4000.

When repair is the elected method for correcting the source of leakage, IWA-4170 requires the repair to be in accordance with the Original Construction Code with provisions to use later Editions of the Construction Code or Section III. The Original Construction Code for the reactor coolant piping is ANSI B31.7 (Reference 3), and the Construction Code used in the design and installation of the subject nozzle is ASME Section III, Subsection NB, 1980 Edition through and including the Winter 1981 Addenda. The Construction Code being used for the alternative repair weld requested herein is ASME Section III, Subsection NB, 1989 Edition.

ASME Section III, Subsection NB requires weld metal defects to either be removed or reduced to an acceptable size. The excavated area is required to be surface examined and the results compared to the acceptance criteria of NB-5340 or NB-5350. Once the defect is either removed or reduced to an acceptable size, repair by welding is permitted to restore the affected area to the required section thickness. The completed repair is then examined in accordance with the Code used in the repair process.

III. REQUESTED ALTERNATIVE

During maintenance activities at Arkansas Nuclear One - Unit 1 (ANO-1), a boron build-up was detected around a Reactor Coolant System (RCS) Instrument Tap in the Loop "A" hot leg for root valves RC-1063/1064 (see Figure 1). Upon further investigation, it was determined that the leakage occurred in the branch connection weld that attaches the nozzle to the hot leg. In total, there are 7 nozzles of common design and six have been identified to have had leakage. Five of the nozzles having indicated leakage and the one that had not leaked are being replaced with a new design to prevent recurrence. Replacement of these six nozzles is in accordance with ASME Section XI (Reference 1). However, the remaining nozzle RC-1071/1072 located on the loop "B" hot leg at elevation 368'5" is located sufficiently below the reactor water level to prevent removal of the nozzle without a full core off-load and subsequent drain down. To perform a full core off-load at this time would result in significant impact to the planned outage. An estimated 22 additional outage days would be required to remove and install a replacement nozzle.

The weld attaching the subject instrument nozzle to the hot leg is designed to be a 3/8 inch partial penetration J-groove with a ¼ inch fillet weld. The weld connects the nozzle to the outside of the hot leg pipe. Liquid penetrant examinations confirm the presence of crack-like indications that are oriented in the circumferential and radial direction of the nozzle weld. All indications are contained within the weld material, and there is no evidence of crack propagation into the base material of the nozzle or the hot leg. Analytical evaluations in accordance with IWB-3600 have demonstrated that the worst case assumed flaws do not significantly penetrate the base metal for the remainder of the operating cycle as described later.

As an alternative to removing or reducing the flaws to an acceptable size and re-welding in accordance with ASME Section III, it is proposed that a full structural overlay weld be installed over the degraded branch connection weld. The request for alternative is limited for the remainder of the current operating cycle. At refuel outage 1R16, the overlay and nozzle will be replaced with a design change meeting all the requirements of ASME Section III and Section XI.

IV. BASIS FOR ALTERNATIVE

Pursuant to the provisions of 10 CFR 50.55a(a)(3)(i) and (ii) it is requested that the repair described in this request for alternative be approved. Compliance with the repair rules as stated in Reference 1 and as described in Section II of this request will result in hardship and unusual difficulty without a compensating increase in the level of quality and safety. Additionally, the proposed alternative does provide an acceptable level of quality and safety as demonstrated by analysis and the following information.

Description of the Nozzle Requiring Repair

The currently installed nozzle was a 1986 field installation (for NUREG-0737) performed in accordance with ASME Section XI complying with the material, design and fabrication rules of Reference 7. The current configuration is illustrated in Figure 2 which is basically an Alloy 600, ¾ inch SCH 160 pipe welded to the OD of the elbow. The elbow is ferritic steel consistent with the requirements of SA-516 GR70 formed in two halves and then welded to form the elbow. The nozzle partial penetration weld may lie partly in the elbow base metal and partly in the weld. The exact location does not affect the conclusion of the acceptability of the repair. The attachment to the elbow is a partial penetration weld sized in accordance with Reference 7. The partial penetration and fillet weld material is a NiCrFe alloy commonly known as Inco 182 or 82. The unique feature of the current design was the installation of an Alloy 600 sleeve in the penetration to shield the ferritic elbow material from the primary coolant. This feature was desirable to limit corrosion that could effect the long-term geometric stability of the penetration and add contaminants to the reactor coolant system. This feature has been shown to be desirable but not necessary (Reference 8).

Repair Suitability Evaluation

In accordance with ASME Section XI, IWA-4150, prior to authorizing repairs a suitability evaluation of the repair including consideration of the cause of failure is required. In assessing the potential mechanisms that may result in indications like those that have been detected in the seven nozzles, it is determined that the most likely contributors would be either fatigue or environmental assisted cracking. To fully understand the fatigue mechanism, a detailed evaluation has been performed as described below:

In order to determine if fatigue might have been a cause of failure, a vibration analysis of a hot leg level tap was conducted. The purpose of this evaluation was to determine the alternating stress at the hot leg to level tap connection.

The hot leg level tap Model #3 was reconstructed from FTI document 32-1164052-01. Without taking credit for the weld overlay, the first frequency was determined to be 24 Hz.

The vibration data applied to the level tap model (+/- 0.5 mils at 20Hz and +/- 0.5 mils at 100Hz) was determined to envelope the hot leg level tap locations. Using structural amplification techniques from Cough and Penzien (Dynamics of Structures, pp 67,68), response spectra were developed at 2% damping for each harmonic excitation. The spectra were then peak broadened 10% and applied to the level tap model in all three directions.

The moments at the hot leg to level tap connection were determined for each harmonic excitation. The moments for each case were combined absolutely and then vectorily combined for the different directions of excitation. This moment represents the ½ range response due to the combination of the harmonic excitations.

The stress indices for a fillet weld (conservative) were applied to determine ½ the peak stress (alternating stress) due to the excitation. The alternating stress is approximately 5 ksi, which is well below the endurance limit of 16.5 ksi.

Therefore, it is concluded that the harmonic excitation could not have caused the failure of the level taps since the resulting stress is well below the endurance limit. The proposed alternative repair of the level tap with the addition of a weld overlay will stiffen the nozzle and further separate the first frequency from the driving frequency. As such, vibration is not a concern for this tap.

The conclusions of the analysis are supported by visual observations and flaw characterization by liquid penetrant examination (PT) with progressive grinding and PT. No evidence of any mechanical or vibration induced failure (over stressed or cyclic) has been detected on any of the seven connections. There was no evidence of material yielding or ratcheting to indicate a tensile overload or a fatigued condition. Typical or expected flaws associated with metal fatigue would be anomalies (i.e. cracks) that are oriented circumferentially around the 3/4" nozzle at the toe of the existing fillet weld. Based on the present characterization of the flaws, the subject connection does not have any distinct anomalies typical of metal fatigue from mechanical mechanisms.

Based on the response of the level tap to the harmonic excitation, it is concluded that the stress at the level tap to hot leg connection is below the endurance limit. As such, vibration is not a concern for the old level taps, for the repaired level tap, nor for the replacement level taps.

Industry history with Inco 182 and 82 in the PWR water chemistry environment combined with the flaw characterizations discovered in each of the seven nozzles implies that the cracking mechanism is environmentally driven. Through the exploratory metal removal, it is evidenced that the indications are initiating from the wetted side of the weld.

The material selected for the overlay, Inco-52 (UNS-N06052) has improved resistance against environmentally induced cracking. This combined with the limited life of the alternative repair (remaining operating cycle) and the extensive analysis discussed below provides assurance that the proposed repair is suitable for its application.

<u>Description of Alternate Repair</u>

The preferred Code repair for this configuration would be to remove the degraded weld metal and possibly the nozzle to restore the pressure boundary and structural attachment with an appropriate design meeting the requirements of References 1 and 4. The presence of the reactor coolant on the inside of the elbow prevents removal of the nozzle and creates a significant risk for any attempt to locally remove the flaws by mechanical means. The surface, however, is currently dry and believed to be suitable for the application of a full structural weld metal overlay.

The repair process will consist of the following steps.

A) The area will be buffed and cleaned suitable for non-destructive testing and subsequent welding. A dimensional inspection will be performed on the existing weld transition from the elbow to the nozzle to insure adequate subsequent coverage of the existing weld with the new weld overlay.

B) A nondestructive examination will be performed on the elbow base metal in the area to be covered by the weld overlay to verify the absence of defects in accordance with Reference 4.

C) An initial weld layer will be applied over the existing branch connection weld and base metal to the extent shown in Figure 3. This weld layer will be ground sufficiently to permit a liquid penetrant examination to verify the absence of defects in accordance with Reference 4.

D) The remainder of the overlay including the fillet weld transition will be applied to meet the requirements of Reference 4. Final weld examination will include an ultrasonic and liquid penetrant examination, and a dimensional verification for compliance with design requirements.

Analysis of Weld Overlay Repair

The weld overlay is evaluated and shown to meet the requirements of Reference 4 for all known loading conditions. This evaluation includes the demonstration of satisfying the primary, primary plus secondary and fatigue requirements of Reference 4. The analysis is performed using the finite element analysis technique assuming elastic behavior. The conventional Section III allowables are shown to be satisfied without use of any of the special alternate provisions such as limit analysis or simplified elastic plastic evaluation. The finite element model is an axisymetric model that includes the existing nozzle, new weld overlay and a portion of the existing elbow. The existing partial penetration weld is assumed structurally ineffective and the load path from the nozzle to the elbow surface is totally through the new weld overlay. The pressure boundary is also assumed to extend to the weld overlay/elbow interface. Branch loads such as seismic and vibrational loads are evaluated by conventional stress analysis techniques (beam and shell type equations) and added to the finite element analysis results as appropriate. As stated in the repair discussion the weld deposit is assumed to have 1/8 inch less effective thickness than the minimum specified weld deposit. This is a conservative allowance for possible degradation of the initial layer over the flawed area.

The remaining evaluations demonstrate that the presence of the flaws in the existing branch connection weld do not restrict operation of the system. The weld overlay will restore the pressure boundary and structural attachment of the branch pipe and the weld overlay is suitable for future service with the underlying flaws.

Analysis of Flaws and their Effect on the Hot Leg

An evaluation (Reference 5) has been performed in accordance with IWB-3640 (Reference 1) to demonstrate the acceptability of the elbow for future service. The flaws were assumed to be the full width of the j-weld prep oriented in the worst condition with respect to the elbow controlling stresses. Due to the low stresses in the elbow pipe wall and the relatively short expected time period of service, this evaluation of a very conservative flaw configuration resulted in a flaw growth in the base metal of less than .06 inches and a maximum calculated end of service condition stress intensity factor of 55 ksi(in)^.5 compared to an allowable of 63 ksi(in)^.5 therefore meeting the acceptance criteria of IWB-3612. The elbow area of interest temperature is sufficiently above the elbow material RT_{ndt} to be on the upper shelf region of the Section XI K_{Ia} curve prior to having significant operating stresses. The elbow service condition period is easily qualified for the remainder of the fuel cycle of less than 2 years assuming 10 heatup/cooldown cycles to the cold condition within the period.

The RT_{ndt} was established in accordance with previous generic evaluation documented in Reference 6. Reference 6 is on file and has been previously reviewed and approved by the NRC Staff. The elbow area RT_{ndt} had been established at 20 degrees F. This was the highest value of the plate material, heat affected zone and weld filler metal. In addition a 50 degree F. increment was added to conservatively allow for possible change due to the weld overlay. The weld size meets the Section III exclusion for fracture toughness testing but the allowance will be added as documented in the weld procedure qualification for the weld procedure which is conservative for this application. Therefore the assumed RT_{ndt} was 70 degrees F.

Analysis of Flaws and Their Effect on the Weld Overlay

The weld overlay is evaluated and shown to meet the requirements of Reference 4 for all known loading conditions. This evaluation includes the demonstration of satisfying the primary, secondary and fatigue requirements of Reference 4. As stated in the repair discussion above the weld deposit is assumed to have 1/8 inch less effective thickness than the minimum specified weld deposit. This is a conservative allowance for possible degradation of the initial layer over the flawed area. The possible degradation could be contributed to an underlying weld defect or a small flaw growth attributed to service conditions.

An evaluation was also performed on the effect of the existing flaws on the new overlay. This evaluation was performed using a very conservative flaw model to calculate the expected flaw growth for the remainder of the current operating cycle (assumed not to exceed 10 heatup/cooldown cycles). The flaw model was assumed to be a 1 5/8 wide center cracked panel with a 5/8 inch long flaw. The ½ inch on each side was a representation of the weld overlay on one side and a symmetry condition assumed on the opposite side. The 5/8 inch center flaw is the depth of the existing J-groove. The flaw is being characterized as a 360 degree flaw around the nozzle normal to the weld pad and fully penetrating the existing J-groove. The stress distribution is assumed to vary linearly from 20 ksi to 58 ksi over the width of the panel. The 20 ksi stress is a conservative existing stress in the elbow which was also used in the ferritic elbow flaw evaluation and the 58 ksi stress is the maximum stress in the weld overlay including allowance for residual stresses. In addition a stress equal to the internal pressure (2.5 ksi) is super imposed to correct for pressure on the crack face. The weld overlay alloy 52/152 has crack growth characteristics equal to or better than the reference curve in App. C of Reference 1. This weld alloy has been confirmed to be resistant to time dependent crack growth phenomena. However, the flaw growth estimated from the Appendix C Curve (R=0.9) is corrected by a factor of two to account for the PWR wetted environment. The results of the crack growth for the remainder of the current operating cycle is less than .01 inches. The first layer (0.125 inches) of the overlay is not taken credit for in the ASME Section III structural analysis and is sufficient to contain all expected flaw growth during the current operating cycle.

V. ALTERNATIVE EXAMINATIONS

In accordance with ASME Section XI, IWA-4710(b), component connections, piping, and associated valves that are NPS 1 and smaller are exempt from pressure tests. However, as part of the alternative repair, the affected nozzle and the weld overlay will be inspected by a VT-2 inspector at or approaching normal operating temperature and pressure. Any evidence of leakage will be cause for rejection.

VI. WHY THE ALTERNATIVE SHOULD BE GRANTED

The IWB-3640 flaw evaluation performed on the effect of the existing flaws on the hot leg, demonstrates that excavation of the flaw would not be required to ensure hot leg pressure boundary integrity. The evaluation conservatively assumed the flaw sizes oriented in the worst condition with respect to the elbow controlling stresses. Even with the conservative assumptions the elbow service life is qualified for the remainder of the fuel cycle with the occurrence of no more than ten cycles. An evaluation was also performed on the effect of the existing flaws on the new overlay. Based on a crack growth rate of less than .01 inch during the remainder of the cycle, the flaws will be contained within the first 0.125 inch of the overlay which is not credited in the structural analysis

The conclusions of the analysis along with the visual observations and flaw characterization provide no evidence of any mechanical or vibration induced failure (over stressed or cyclic), neither are there any distinct anomalies typical of metal fatigue from mechanical loading or mechanisms. Also, there was no evidence of material yielding or ratcheting to indicate a tensile overload or a fatigued condition. Based on industry history with Inco 182 and the characterization of the flaws seen at ANO Unit 1 evidence supports that the present flaws are environmentally induced.

Providing a weld overlay using Inco-52 (UNS N06052 filler metal) material provides a well documented resistance to environmental cracking. Therefore, unacceptable degradation during the relatively short operational period prior to replacement in not expected

The alternate weld overlay design and installation meets all of the requirements of Section III (Reference 4).

Based on the acceptable IWB-3640 flaw evaluation performed on the elbow; the weld overlay's resistance to the possible degradation mechanisms; the low crack growth rates; and the limited life of the alternative, the weld overlay will provide an acceptable level of quality and safety without performing the Code-required flaw excavation. Furthermore, the additional twenty-two days of extended outage to perform the Code-required flaw excavation or nozzle replacement, would cause a hardship without a compensating increase in the level of quality and safety.

Therefore, Entergy Operations believes that the proposed alternative meets the criteria of 10 CFR 50.55a(a)(3)(i) and (ii).

RCS Level Instrument Tap Locations

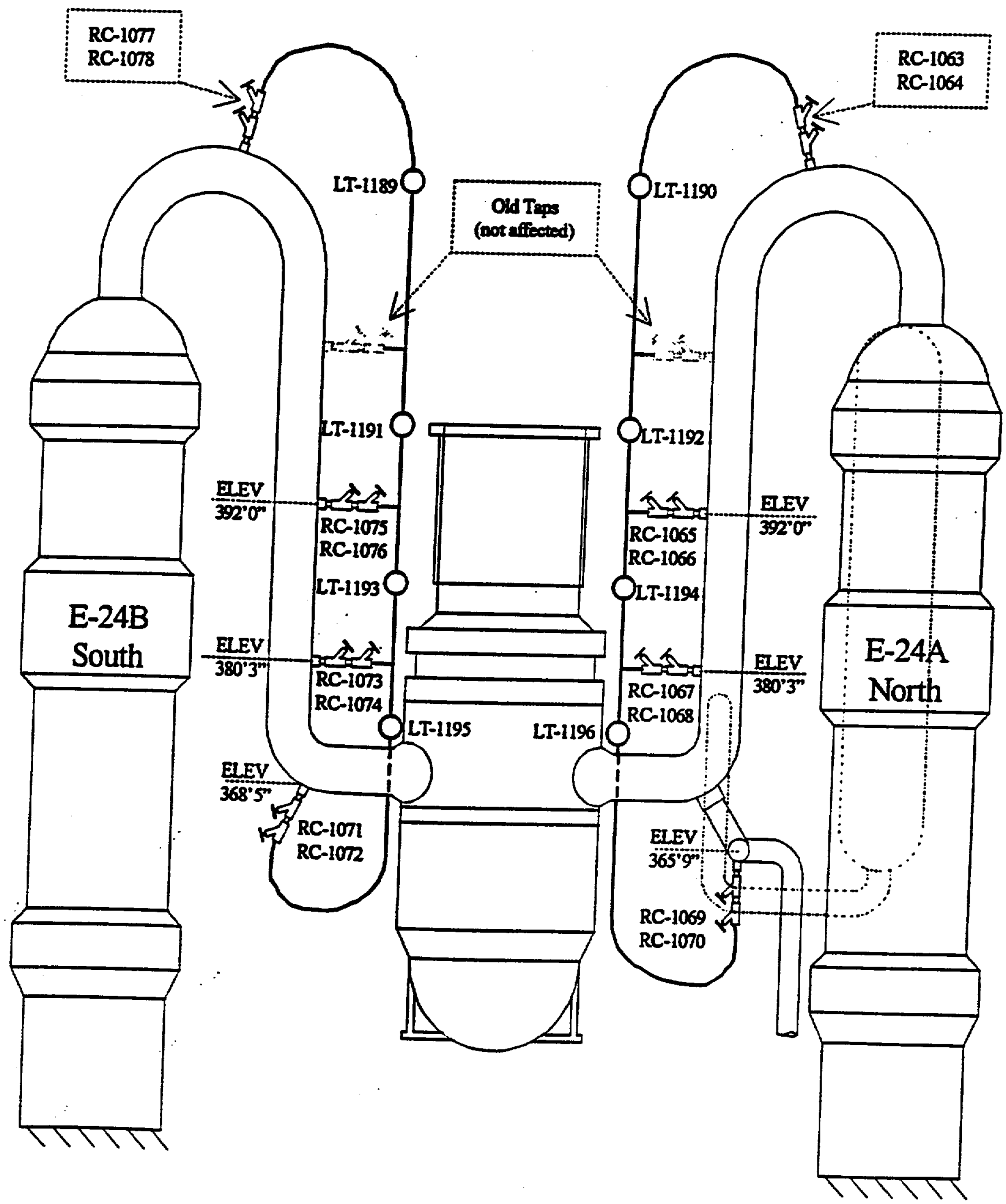
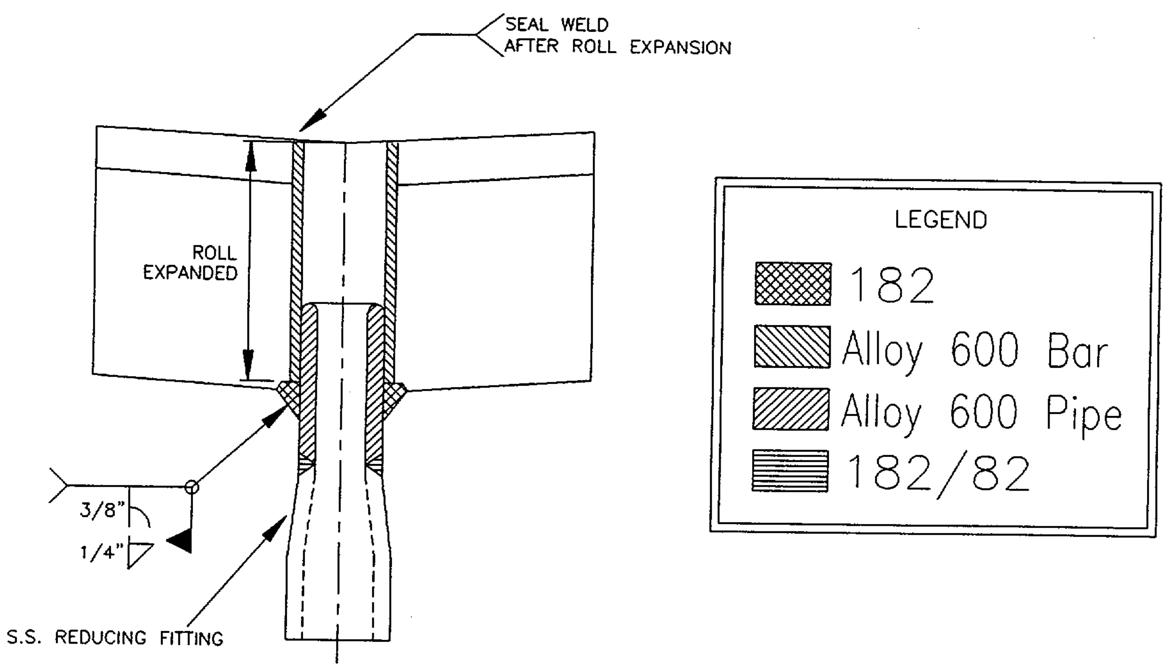
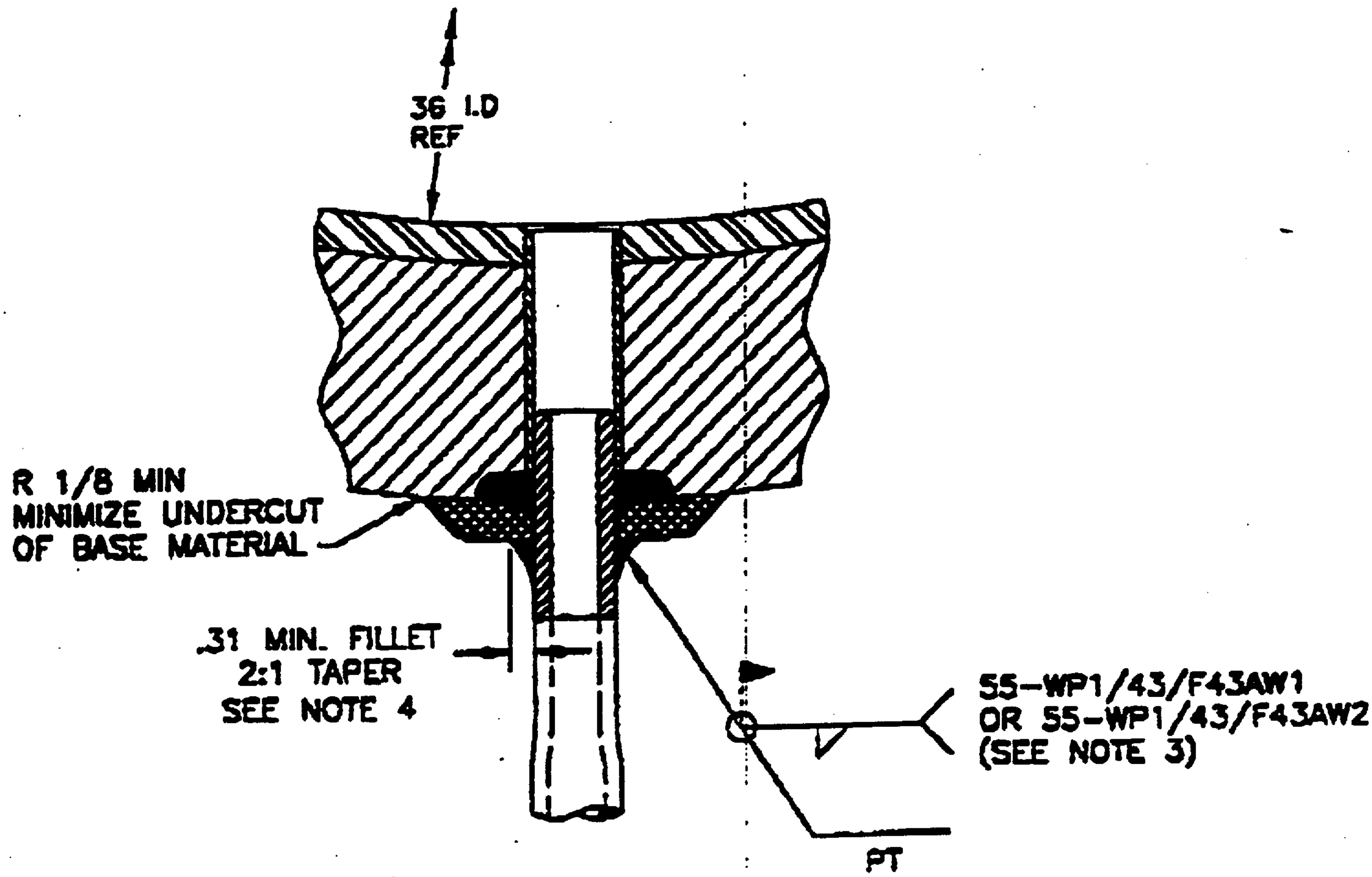


Figure 1



Original Hot Leg Nozzle Configuration

Figure 2



Fillet Weld for Alternate Repair

Figure 3