October 4, 2004

10 CFR 50.55(a)

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

Nuclear Management Company Response to Request for Additional Information RE: Relief Requests for Reactor Vessel Head Penetrations at the Palisades Nuclear Plant

By letter dated August 2, 2004, Nuclear Management Company, LLC (NMC) requested relief from certain sections of the American Society of Mechanical Engineers (ASME) Code in the event a reactor vessel head penetration nozzle is in need of a repair at the Palisades Nuclear Plant.

On September 16, 2004, NMC received a request for additional information (RAI) from the NRC staff on the relief requests. The RAI was discussed with the NRC staff per teleconference on September 20, 2004 and September 29, 2004.

NMC is providing the responses to the RAI. Enclosure 1 contains the NMC responses for the Palisades Nuclear Plant.

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

Daniel J. Malone
Site Vice President, Palisades Nuclear Plant
Nuclear Management Company, LLC

Enclosure (1)
Attachment (1)

CC Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

A047

ENCLOSURE 1
NUCLEAR MANAGEMENT COMPANY RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION RE: RELIEF REQUESTS FOR REACTOR VESSEL HEAD PENETRATIONS AT THE PALISADES NUCLEAR PLANT

Background

Framatome ANP (FANP) has performed 67 temperature inside diameter temper bead (IDTB) control rod drive mechanism (CRDM) nozzle repairs, as shown in the table below. There have been no in-core instrumentation (ICI) IDTB repairs performed to date. The response to question 1, part (1), defines the repair process and refers to attached figures of the repair process for Palisades. The repair process is the same for the CRDM nozzles and the ICI nozzles except for geometry differences. Millstone 2 and St. Lucie 2 are Combustion Engineering (CE) plants where a lower replacement nozzle was welded to a similar configuration as Palisades, using the IDTB repair process. The major differences at Palisades are:

- Palisades has a long nozzle extension that attaches to the bottom of the replacement nozzle, where Millstone and St Lucie have short guides (funnels) that attach to the bottom of the replacement nozzle.
- Palisades has a grid structure that ties the lower portion of the CRDM nozzle extensions together.
- The outside diameter (OD) of the nozzle at Palisades is smaller. The machining diameter for removing a portion of the nozzle is the same as Millstone. The nominal ID of the nozzle is the same or within 0.010" of each other.

The repair process and analyses for Palisades are the same as those for Millstone 2, St Lucie 2, and Calvert Cliffs 1 and 2, except for slight geometry differences and different operating transients.

NUCLEAR POWER PLANT	INTERVENTION DATE	FANP IDTB REPAIR EXPERIENCE TYPE OF REPAIR
OCONEE 2	05/01	Remote ID Temper Bead Process on 4 nozzles
CRYSTAL RIVER 3	10/01	Remote ID Ambient Temper Bead Process on 1 nozzle
TMI 1	10/01	Remote ID Ambient Temper Bead Process on 6 nozzles
SURRY 1	11/01	Remote ID Ambient Temper Bead Process on 6 nozzles
OCONEE 3	12/01	Remote ID Ambient Temper Bead Process on 7 nozzles
MILLSTONE 2	3/02	Remote ID Ambient Temper Bead Process on 3 nozzles
OCONEE 1	4/02	Remote ID Ambient Temper Bead Process on 2 nozzles
DAVIS-BESSE	4/02	Remote ID Ambient Temper Bead Process on 5 nozzles
OCONEE 2	11/02	Remote ID Ambient Temper Bead Process on 15 nozzles
ANO 1	11/02	Remote ID Ambient Temper Bead Process on 6 nozzles
ST. LUCIE 2	5/03	Remote ID Ambient Temper Bead Process on 2 nozzles
MILLSTONE 2	11/03	Remote ID Ambient Temper Bead Process on 8 nozzles
ANO-1	5/04	Remote ID Ambient Temper Bead Process on 1 nozzle
POINT BEACH 1	5/04	Remote ID Ambient Temper Bead Process on 1 nozzle

Nuclear Regulatory Commission (NRC) Requested Information

By letter dated August 2, 2004, Nuclear Management Corporation (NMC) requested relief from certain sections of the ASME Code Section XI in the event a reactor vessel head penetration nozzle is in need of a repair at Palisades. NMC submitted two relief requests. Relief request number 1 is related to the alternate repair technique and relief request number 2 is related to flaw characterization. To complete its safety evaluation, the staff requests the following information.

Relief Request #1-Alternate Repair Technique

Questions on Enclosure 1 to Relief Request #1

1. The reactor vessel head penetration repair is described briefly on page 4 of AREVA document 32-5043862 in Attachment 2 to Relief Request #1. The staff needs detailed description. (1) Submit a document (or reference a document that has been submitted previously) that describes the repair plan, or discuss in detail step-by-step repair of the control rod drive (CRD) nozzle and incore instrumentation (ICI) nozzle. (2) The discussion should include physical dimensions of the components such as wall thickness, diameter, length of the CRD and ICI nozzles, and thickness of the repair weld. (3) Discuss how the lower portion of the nozzle is removed from the closure head bore and detached from the J-groove weld. (4) Discuss whether removal of the nozzle will cause crack initiation in the J-groove weld. (5) Discuss why the inside of the replacement nozzle is divided into several segments with various inside diameters and wall thickness. (6) Discuss whether various inside diameters in the replacement nozzle will cause lateral movement of the control drive mechanism shaft. (7) Discuss whether the metal surfaces (base metal and original nozzle) are cleaned before the repair weld is made.

Nuclear Management Company (NMC), LLC Response

1. (1) A detailed process outline of the control rod drive mechanism (CRDM) and in-core instrumentation (ICI) nozzle repair is described below. Provided in Attachment 1 are figures that show the nozzle configuration during the process. The repair process is the same for the CRDM and ICI nozzles, except as noted in the process outline.

   a. Ultrasonic (UT) the weld repair area.
   b. Cut tube grid structure adjoining the target nozzle and surrounding CRDMs. (CRDM only)
   c. Cut the nozzle and remove the nozzle extension close to the underside of the head.
   d. Roll expand nozzle body.
   e. Clean the bore.
   f. Bore the lower nozzle OD slightly oversize up to the location of the repair weld. The lower portion of the remaining nozzle is beveled suitable for welding.

g. Machine the replacement lower nozzle (diameter and length).
h. Grind chamfer on original attachment weld.
i. Clean the weld prep area.
j. Liquid penetrant (PT) the weld prep and exposed low alloy steel base material.
k. Clean PT consumables from weld prep and dry nozzle and crevice using heating element.
l. Insert new CRDM/ICI replacement lower nozzle and weld using the ambient temperature temper bead machine gas tungsten arc welding (GTAW) process.
m. Cool down; 48-hour hold.
n. Machine new weld to re-establish nozzle free-path and to provide a surface suitable for UT. This may be performed during the 48-hour hold.
o. UT the weld after 48-hour hold.
p. Install foreign material exclusion (FME) plug.
q. Abrasive waterjet (AWJ) (remediate) starting above the roll transition, original lower nozzle, and weld.
r. Perform visual inspection of remediated area.
s. Remove FME plug.
t. PT weld and roll expanded portion of CRDM/ICI nozzle, including the roll transition region and AWJ area.
u. No-go gage the weld and nozzle bore.
v. Install the new extension assembly (and tube grid structure for CRDM locations).
w. Position and weld the new tube grid structure and the new extension assembly. (CRDM only)
x. Visually inspect the new welds.
y. Dimensional inspect the location of the new nozzle extension assembly.
z. Perform free-path check of completed nozzle modification. (CRDM only)
aa. Perform final cleaning and visual inspection of each CRDM/ICI nozzle.

(2) Physical dimensions of the components such as wall thickness, diameter, and length of the CRD and ICI nozzles are FANP and Westinghouse proprietary data. The nozzle diameters are contained on Page 14 of the CRDM ASME Analysis (AREVA Document 32-5044089) and on Page 13 of the ICI ASME Analysis (AREVA Document 32-5042479). The weld thickness can be calculated from the replacement nozzle diameters ({OD – ID} / 2).

(3) Removal of the lower portion of the CRDM/ICI nozzle is accomplished in three steps. Step 1 - The grid structure legs connecting to the nozzle extension at the repair location are cut (CRDM only). Step 2 - The nozzle is severed a few inches below the inside of the reactor vessel closure head (RVCH). Step 3 - The lower portion of the CRDM/ICI nozzle is machined away to a specified depth inside the RVCH that ensures the original attachment weld no longer contacts the lower portion of the CRDM/ICI nozzle.

(4) The J-groove weld has a high tensile stress state due to welding residual stresses that could promote primary water stress corrosion cracking (PWSCC) initiation. Removal of the nozzle will impart some additional cold work and tensile stress on the newly machined ID surface of the J-groove weld. The effect of the machining and cold

work is not expected to affect the susceptibility of the J-groove weld to PWSCC since it is already in a highly stressed state and has a high susceptibility. After the IDTB repair, the J-groove weld is no longer part of the pressure boundary and an ASME Section XI analysis is provided justifying a radial planar flaw in the J-groove weld.

(5) The replacement nozzle ID contains 3 different diameters. In the installed orientation, the upper ID matches the ID of the original CRDM/ICI nozzle. The middle ID is slightly larger than the upper ID so that the time required to final machine the new weld is minimized (total length of the replacement lower nozzle machined is limited to length of upper ID). The lower ID is slightly larger than the middle ID so that the replacement nozzle extension can "nest" inside the replacement nozzle, thereby creating a smooth transition. (See step 7 of the attached CRDM repair figures provided in Attachment 1).

(6) Various diameters in the replacement nozzle will not cause lateral movement of the CRDM. The ID of the nozzle does not provide a guide for the CRDM. The close alignment of the CRDM system is achieved by the tightly controlled tolerances of the component design.

(7) The repair process states that prior to welding, the lower portion of the CRDM/ICI nozzle is beveled suitable for welding. The weld prep area (CRDM/ICI nozzle and base metal) is then cleaned and a PT exam is performed. PT consumables are then cleaned from the weld prep area and the nozzle ID. Next, a heating element is used to dry the penetration ID.

NRC Requested Information

> *2. Page 4. Item 8. NMC stated that NB-4622.8(a) does not apply because it involves buttering layers at least 1/4-inch thick which will not exist for the welds in Palisades repair. Discuss the buttering layer in the Palisades repair.*

NMC Response

> 2. The buttering layer does not apply specifically to the Palisades RVCH CRD/ICI penetration weld repair.
>
> The ferritic low alloy steel will be exposed to the welding arc subsequent to removal of the lower end of the nozzle. That is why the temper bead welding process is required.

NRC Requested Information

> *3. Page 4. Item 11.B. NMC stated that the proposed alternative "will" include the same limitation as specified in NB-4622.11(b), which limits defect removal not exceeding 3/8-inch in the base metal. However, the staff could not find this*

requirement in the proposed alternative repair method in Attachment 1 to Relief Request #1. NMC must include the limitation in its alternative repair technique in Attachment 1.

NMC Response

3. The "Justification of Relief" section (page 7 of 14) specifies that the requirements specified in the "Alternate Repair Technique" shown in Attachment 1 of Relief Request #1 will be followed, except as stated in this section. Attachment 1.0 (c) specifically addresses the 3/8-inch maximum base material removal thickness (depth) as a limiting requirement. Furthermore, paragraph 4 (page 9 of 14) also mentions the 3/8-inch maximum excavation depth limit.

NRC Requested Information

4. Page 5. Item 8 (and Page 10. Item 6). NMC stated that the temperature for pre-heat is 50 degrees F instead of 100 degrees F required by NB-4622.11(c)(8). NMC stated that this approach (50 Degrees F preheat) has been demonstrated to be adequate to produce sound welds. Describe the performance demonstration and reference the document(s) of the demonstration.

NMC Response

4. AREVA welding procedure qualification tests have been performed on P-No. 3 Group No. 3 base materials using Alloy 52 filler metal at ambient (essentially room) temperature. These welding procedures were developed in accordance with ASME Section XI, Code Case N-638.

NRC Requested Information

5. Page 8. Item g (and Page 10. Item 7). N-638 4.0(b) requires the weld surface and band around the weld area to be examined using surface and ultrasonic examination. As an alternative, NMC proposed to examine the new weld and immediate surrounding area within the bore. Describe the physical dimension of the total examination area if N-638 4.0(b) requirement is applied and of the examination area if the proposed alternative repair method is applied to the CRD and ICI repair. Discuss assessment that the proposed examination area is adequate as compared to the requirements in N-638 4.0(b).

NMC Response

5. The preheated band as specified in 4.0(b) of N-638, includes an annular area extending 5 inches around the penetration bore on the inside surface of the RVCH. The purpose for the examination of the band is to ensure all flaws

associated with the weld repair area have been removed or addressed since these flaws may be associated with the original flaw and may have been overlooked. In this case, the repair welding is performed remote from the known flaw(s).

As described in Enclosure 1 of Relief Request #1, it is impractical to examine the band required by N-638, 4.0(b) due to the head configuration and interference from adjacent CRDM nozzles, as well as the configuration of the partial penetration welds. The proposed alternative examination area includes the weld and adjacent base material to be examined by PT and UT methods in the regions shown in Figures 3 and 4 of Attachment 1 to Relief Request #1.

Scanning is performed from the inside surface of the new weld, the adjacent portion of the original nozzle, and the top of the new lower nozzle. The volume of interest for UT extends from at least ½-inch above and below the new weld into the RVCH low alloy steel base material to at least ¼-inch depth. The PT area includes the weld surface and extends upward on the original nozzle inside surface to include the abrasive water jet remediated surface (approximately 2.7 inches on the CRDM nozzles and approximately 3.1 inches on the ICI nozzles) and at least ½-inch below the new weld on the lower nozzle inside surface.

The final examination of the new weld and immediate surrounding area of the weld within the band will be sufficient to verify that defects have not been induced in the low alloy steel RVCH material due to the welding process, and will assure integrity of the nozzle and the new weld.

The response to Item 6 contains more information about the comparison to the requirements in N-638.

NRC Requested Information

6. Page 8. Item i. N-638 4.0(e) requires UT acceptance criteria to be in accordance with IWB-3000. However, NMC stated that its UT acceptance criteria will follow NB-5330, which is consistent with the original construction code requirement. NMC needs to discuss the differences on UT acceptance criteria between NB-5330 and IWB-3000 and discuss why the UT acceptance criteria is NB-5330 is adequate.

NMC Response

6. N-638, 4.0(e) requires UT acceptance criteria to be in accordance with IWB-3000. However, for this configuration, there are no acceptance criteria in IWB-3000 that directly apply. Therefore, the Section III NB-5330 construction code criteria are used. These criteria are generally more restrictive than

Section XI standards because the NB-5330 standards do not permit many common welding flaws such as lack of fusion, incomplete penetration, or cracks, regardless of length. Section XI, IWB-3000 standards allow acceptance of these types of fabrication indications based on dimensioned flaw boundaries.

NRC Requested Information

7. Page 12. Last paragraph and page 13, 1st paragraph. NMC stated that if the weld repair is not abrasive water jet machining (AWJM) remediated, the life expectancy relative to PWSCC is conservatively estimated at 1.3 effective full power years for a CRD and 1.5 EFPY for an ICI nozzles. If AWJM is used, the life expectancy relative to PWSCC is 53 EFPY for CRD and ICI nozzles. On the basis of Item 1.0(f) in Attachment 1 to Relief Request #1, AWJM will be used at Palisades. (1) Describe the AWJM procedure, including water jet conditions and forces that will be exert on the weld surface. (2) Discuss the possibility of improper use of AWJM that would cause negative effect on the weld. (3) Discuss how a life expectancy of 53 EFPY for applying AWJM is derived. (4) Code Case N-638 1.0(f) specifies that peening may be used, except on the initial and final layers. Peening is not allowed on the last layer of the weld presumably to minimize the cold work on the weld and peening may mask potential surface crack(s) from being detected during post-weld examinations. Discuss whether AWJM would cause these issues.

NMC Response

7. (1) The AWJM procedure passes a high-pressure jet of water, combined with an abrasive, over the surface in a circumferential-axial direction. The AWJM area extends from below the toe of the IDTB weld to above the roll expansion line. AWJM is performed at ambient temperature and as a result of the abrasive, a small surface layer is removed. The impact of the abrasive particles induces compressive forces on the surface being remediated. The remaining surface is left in a state of compression, thereby mitigating PWSCC.

(2) AWJM is a repeatable controlled process that has been used in the field dozens of times to remediate RVCH nozzle repairs without a negative impact on the IDTB weld. The IDTB weld is made from Alloy 52, which is highly resistant to PWSCC in the as-welded state. AWJM applied to the surface of the weld will improve the surface stress state and further enhance its resistance to PWSCC.

(3) A surface layer that is left in a compressive stress state after AWJM will slowly undergo general corrosion, as do all corrosion resistant alloys in the primary system. 53 effective full power years (EFPY) is derived by calculating the time for the compressive stress layer to be breached due to general corrosion, then assuming immediate PWSCC initiation with rapid crack propagation.

(4) AWJM is a surface ablative process and is not considered peening. AWJM does impart some cold work along with the compressive residual stresses along the surface layer. The same surface in the as-repaired non-AWJM condition will have cold work associated with the final machining necessary to perform the final non-destructive examination (NDE). Undoubtedly, the overall state of the IDTB weld is improved with the use of AWJM remediation. With regard to smearing of metal to mask cracks, AWJM is an ablative process that uniformly removes material from the surface in extremely small particles. This is unlike the type of surface plastic deformation seen using a peening process. Final UT and PT are performed to insure the integrity of the IDTB weld.

NRC Requested Information

Questions on Attachment 1 to Relief Request #1

8. Page 4. Item d. NMC stated that NDE personnel will be qualified in accordance with IWA-2300 or NB-5500. Code Case N-638 4.0(d) specified IWA-2300 only. Discuss any difference between IWA-2300 and NB-5500 in terms of NDE personnel qualification.

NMC Response

8. The 1992 Edition of Section XI, IWA-2300, and Section III, Article NB-5500, both require NDE personnel to be qualified in accordance with the 1984 Edition of SNT-TC-1A. Therefore, there are no differences in either Code references with respect to NDE personnel certification. The AREVA written practice addresses this Edition of SNT-TC-1A.

NRC Requested Information

9. Discuss why the requirements in Code Case N-638 3.0(e) is not included in the Alternate repair Technique in Attachment 1. This item specifies that the weld region shall be free of hydrogen and the weld surface, filler metal, and shielding gas shall be controlled.

NMC Response

9. Code Case N-638, paragraph 3.0(e), was inadvertently omitted from Attachment 1. This paragraph states:

> "(e) Particular care shall be given to ensure that the weld region is free of all potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled."

The welding process control documents ensure the requirements of this paragraph are accomplished.

NRC Requested Information

Questions on Attachment 2 to Relief Request #1

10. AREVA assumed a triple point weld anomaly of 0.100 inch deep and 360 degree semi-circular flaw around the circumference of the nozzle. Discuss the basis of assuming a depth of 0.1 inch.

NMC Response

10. During initial mock-up testing, triple point weld anomalies were found in some of the mockups. The triple point weld anomalies found were less than 0.100-inch deep, therefore, a conservative triple point weld anomaly of 0.100-inch deep and 360-degree semi-circular flaw around the circumference of the nozzle was assumed. Indications of the conservatively large size of 0.100-inch have not been observed in inspections of the 67 RVCH IDTB repair welds that AREVA has performed to date.

NRC Requested Information

11. Figure 1 shows that the repair weld metal extends into the reactor vessel closure head base metal. Also in Table 10, the weld in the replacement nozzle show thicker wall than the original nozzle (0.5 inch vs. 0.297 inch). (1) Discuss whether the closure head bore will be machined to expand the inside diameter of the bore to fit the thicker walled (i.e., larger outside diameter) replacement nozzle than the original nozzle. Discuss the kind of fit between the replacement nozzle and the closure head bore. (2) However, the extra thickness of the repair weld of the replacement nozzle is not shown in the finite element model of the repair weld in Figure 3. Discuss the discrepancy between the finite element model and actual repaired nozzle dimensions.

NMC Response

11. (1) The RVCH penetration is bored out slightly larger than the CRD nozzle OD. As-built measurements of bore ID are recorded and the replacement nozzle is machined for a 0.010-inch to 0.020-inch diametrical clearance with the bore.

(2) The Dominion Engineering finite element model in Figure 3 was used to generate residual stresses from the original welding, nozzle removal, and rewelding. Due to complexities associated with three-dimensional modeling and nonlinear, elastic-plastic stress analysis, a somewhat simplified model was used for this application. The residual stress model provides sufficient detail, however, to capture the overall trend for the distribution of residual stress through the nozzle wall.

NRC Requested Information

12. Page 29. AREVA discussed residual stresses in the repair weld and discuss how Dominion Engineering Inc modeled stresses; however, the staff is not clear how the welding residual stresses are considered by AREVA in its flaw evaluations. Discuss how the residual stresses are modeled in the crack stability calculations. Discuss whether the residual stresses are applied to the crack face as a constant load.

NMC Response

12. The stresses used for the flaw evaluations are the sum of residual stresses from Dominion Engineering and operating stresses (pressure and thermal) due to transient events, as shown, for example, in Table 10 on page 40 for a circumferential flaw. In this example, the total stress is used to calculate stress coefficients for use with a Buchalet and Bamford closed-form solution for stress intensity factors.

NRC Requested Information

13. Page 36. AREVA stated that flaw evaluations used stresses from residual stresses and fatigue stresses. Discuss whether stresses from normal operation (e.g, thermal) and accident conditions are included in the flaw evaluations per ASME Code Section XI, IWB-3600.

NMC Response

13. As used here, the term "fatigue stresses" includes all pressure and thermal stresses used in the Section III fatigue stress analysis for normal and upset transient loading conditions. The accident conditions were considered, but not included. The accident conditions are not controlling because of the lower margin $\sqrt{2}$ for the accident condition as compared to $\sqrt{10}$ for normal and upset conditions.

NRC Requested Information

14. Page 46. Discuss the types/kinds of loadings applied in the normal conditions and upset conditions in calculating the stress intensity factors. Clarify whether wall position at 0.0 inch is inside-diameter surface or outside-diameter surface of the nozzle.

NMC Response

14. Stress intensity factors are calculated from worst-case stresses for the eight transients listed on page 11. Tables 1 through 8 include pressure and thermal stresses for the Section III fatigue analysis for the eight transients listed on page 11. Stress intensity factors are calculated using worst-case stresses for each flaw evaluation. As indicated on page 46 for the axial flaw evaluated in Table 12, the maximum stresses are due to safety valve operations and the minimum stresses occur during the heatup/cooldown transient. The 0.0-inch wall position is located at the assumed weld anomaly on the outside surface of the nozzle.

NRC Requested Information

Questions on Enclosure 2 to Relief Request #2

15. Page 3. 3rd paragraph and page 7 Item 2 in Attachment 1 to Relief Request #2. NMC stated that it is not necessary to consider residual stresses for crack growth into a compressive residual stress field. In a recent submittal by Entergy on the repair of the reactor vessel closure head penetrations at ANO-1, Entergy did not diminish the residual stresses on the crack tip by the compressive stress field. In light of ANO-1 analytical approach, NMC needs to explain its analytical approach with respect to the weld residual stresses. (1) Discuss where in the weld metal or base metal where residual tensile stresses become compressive stresses and discuss how this demarcation is determined. (2) Discuss how large (length or depth) of the postulated flaw is increased to account for the residual stresses. (3) Discuss the location of the crack tip with respect to the base metal, butter, and J-groove weld. (4) Discuss the nature of residual stresses that can be reduced by the compressive stress of the base metal.

NMC Response

15. Residual stresses transition from tensile in the area of the weld to compressive at some distance into the head. These stresses were addressed by increasing the size of the original postulated flaw size in the weld and butter to include the zone of tensile residual stress in the head. Thus, residual stresses are not reduced by compressive stresses in the head, but rather, tensile residual stresses are relieved as the crack propagates through the weld and butter and into the head.

(1) The demarcation between tensile and compressive residual stress was determined along the bored surface since this is the location of the highest stress intensity factor. Residual hoop stresses along the bored surface of the head were extracted from the Dominion Engineering stress analysis. These stresses are listed in Table 1 on page 15 of AREVA Document 32-5044161-00, starting from the butter/head interface (node 82711 in Figure 7). The transition from tensile to compressive stress occurs at a distance of 0.640" into the head.

(2) The size of the postulated flaw (in the weld and butter) along the bored surface ("b" dimension) was then increased by this amount to account for the presence of residual stress. The other characteristic flaw parameter, the horizontal distance "a", was increased by this same amount after correcting by the direction cosine of the normal to the crack front at position "1" (see Figure 8).

(3) The location of the crack tip is discussed above.

(4) The treatment of residual stress is discussed above.

NRC Requested Information

16. Page 3. 2nd paragraph. NMC stated that a flaw in the J-groove weld would propagate by primary water stress corrosion cracking. Discuss whether other forces are considered in driving the flaw to propagate such as residual stresses in the weld, normal and accident operating loads.

NMC Response

16. The flaw evaluation postulated that a worst-case flaw was present in the weld and butter. To create such a flaw, a small defect would have propagated by PWSCC under the influence of residual and steady state stresses, and to a much lesser degree, by fatigue crack growth due to cyclic operating stresses. The accident conditions were considered but not included. The accident conditions are not controlling because of the lower margin $\sqrt{2}$ for the accident condition as compared to $\sqrt{10}$ for normal and upset conditions.

NRC Requested Information

Questions on Attachment 1 to Relief Request #2

17. Flaw Size. Various flaw sizes are shown from pages 20 to 47. The summary of results of initial flaw size (a = 1.096 inch and b = 1.635 inches) and final flaw size (a = 1.54 inches and b = 2.17 inches) are shown on page 47. However, the flaw sizes shown on pages 20, 22, 32, 35, 38, 41, 44 are different from the flaw size of page 47. Explain various flaw sizes from pages 20 to 47 (e.g. why are the flaw sizes assumed and how are they derived).

NMC Response

17. Four finite element models were generated for the CRDM nozzle repair; a stress model to obtain residual stresses, a stress model to obtain operating (fatigue) stresses, and two crack models to generate influence coefficients for evaluating the range of flaw sizes produced by fatigue crack growth. The flaw sizes ("a" and "b") on page 20 and 22 are from the two crack models, which should represent flaws that are similar in shape to the postulated flaws

(analogous to a Raju-Newman semi-elliptical flaw model being used to represent an actual surface flaw indication). The postulated flaw sizes ("a_p" and "b_p") on page 47 are the J-groove weld dimensions from the fatigue stress model. The two sets of flaw sizes are very close (a = 0.617 inches vs. 0.629 inches and b = 0.995 inches vs. 0.995 inches), which validates the crack model influence coefficients for use in the present flaw evaluations. The initial flaw sizes shown on page 47 are derived on page 23 by adding the residual stress correction to the postulated flaw sizes to obtain a = 1.096 inches and b = 1.635 inches.

As discussed on page 12, the fatigue crack growth analysis is performed by linking the incremental crack growth between Tables 4 through 11. This means that rather than calculating fatigue crack growth for each individual transient over a 27 year period and then adding the results of "independent" transient events, a more realistic approach is taken wherein fatigue crack growth is calculated on a yearly basis for a subset of cycles for each transient before proceeding to the next year. Thus the "beginning" flaw sizes for the transients in Tables 5 through 11 are the starting sizes for a given transient after crack growth during the first year of the previous transient. The final flaw sizes on page 47 are from Table 4, which contains data through the <u>end</u> of the current operating license, and beyond (considering all eight transients).

NRC Requested Information

18. Page 20. Discuss why a small flaw and a large flaw are postulated in the analysis. Discuss the connection between the flaw sizes (small and large) on page 20 and the flaw sizes (initial and final) on page 47.

NMC Response

18. The small and large flaw crack models are used to develop analytical stress intensity influence coefficients (the solution method) used in the actual flaw evaluations. For general applications they are intended to represent flaws that are similar in shape to actual, or in this case, postulated flaws. Otherwise, an iterative process involving crack growth analysis and crack model development would be required to exactly match the flaw sizes, which is resource prohibitive. Indeed, the philosophy behind the influence coefficient solution method is to eliminate the need to develop a specific finite element crack model for each flaw evaluation. Please also refer to the response to Question 17.

NRC Requested Information

19. Page 51. Explain the J-groove weld center offset and downhill J-groove offset. Discuss how cladding on the reactor vessel closure head (thickness and material property) is considered in the flaw evaluation.

NMC Response

19. The J-groove weld center offset (0.25-inch) is the horizontal distance between the pilot hole and the origin of the J-groove radius. The downhill J-groove offset is the horizontal distance between the pilot hole and the vertical portion of the downhill J-groove (this horizontal "cutoff" is shown in Figure A-1 on page 50). The 0.25-inch thick cladding is included in the finite element crack model using stainless steel material properties (page 52). In the flaw evaluations, it is treated in the same fashion as any other material by specifying the appropriate material properties. As the flaw propagates beyond the butter and into the head, the crack front is conservatively assumed to extend all the way through the cladding to the inside surface.

NRC Requested Information

20. Page 51. J-groove height is reported to be 1.5625 inches and butter thickness is 0.3125 inches. If a crack is assumed in J-groove weld and butter, the crack would have a depth of 1.87 inches (1.56 + 0.31 = 1.87). The initial flaw assumed in the analysis as reported on page 47 is 1.096 inch in the "a" direction and 1.635 inches in the "b" direction. AREVA stated in the report that a worst-case flaw is assumed to exist in the J-groove weld and that the crack tip is located at the interface between the butter and the base metal. However, on the basis of above estimate, the initial flaw assumed in the analysis as shown on page 47 is not the worst-case flaw because either "a" or "b" direction dimension is less than 1.87 inches. Discuss whether the worst-case flaw size was assumed in the analysis.

NMC Response

20. There are several issues here. The J-groove height is a construction dimension prior to final machining of the bore (it is actually decreased by the final machining). The butter is deposited inside the J-groove weld prep, so that it does not add to a flaw size based on the J-groove excavation depth. Furthermore, the flaw size dimension "b", shown in Figure 8 on page 18, is measured from the bottom of the chamfered weld. Thus, the postulated flaw dimension "b_p" on page 23 is actually less than the construction J-groove height (1.5625 inches). After addition of the residual stress penalty, the initial "b" dimension is 1.635 inches.

NRC Requested Information

21. Page 53. The internal pressure was considered the only applied load. Discuss why thermal expansion and other normal operation and transient loads not considered as applied loads.

NMC Response

21. Appendix A to AREVA Document 32-5044161-00 serves two purposes. It first describes the finite element crack model used to calculate stress intensity factor influence coefficients. Secondly, it performs a sample calculation for a pressure only load (2485 psig) for demonstration purposes. The results of this calculation (Table A-1 on page 59) are later used in Table B-3 on page 70 to validate the influence coefficient solution process. The stresses used for the actual flaw evaluations (Tables 4 through 11) include the effects of the mechanical and thermal loads considered in the Section III fatigue stress analysis.

NRC Requested Information

22. Page 56. Discuss the basis of the statement "...Along the crack front, these elements are collapsed to form wedges with the appropriate mid-side nodes shifted to quarter-point locations to simulate the singularity at the crack tip..." When removing a segment of the elements in the finite element model and replacing the segment with a crack element model, discuss whether the stresses of the elements that surround the crack elements would have the corrected stresses because the crack elements were not a part of the original/initial finite element analysis. Discuss whether this replacement would give non-conservative stresses.

NMC Response

22. Elements are removed and replaced with the crack element sub-model prior to loading the model. The outer boundary nodes of the crack model are merged with coincident nodes in the basic model so that there is complete continuity between the two portions of the composite model. This method does not produce non-conservative stresses.

NRC Requested Information

23. Page 59. The flaw size shown in Table A-1 is different from the initial flaw or final flaw size shown on page 47. Explain why either the initial or final flaw size is not used in Table A-1.

NMC Response

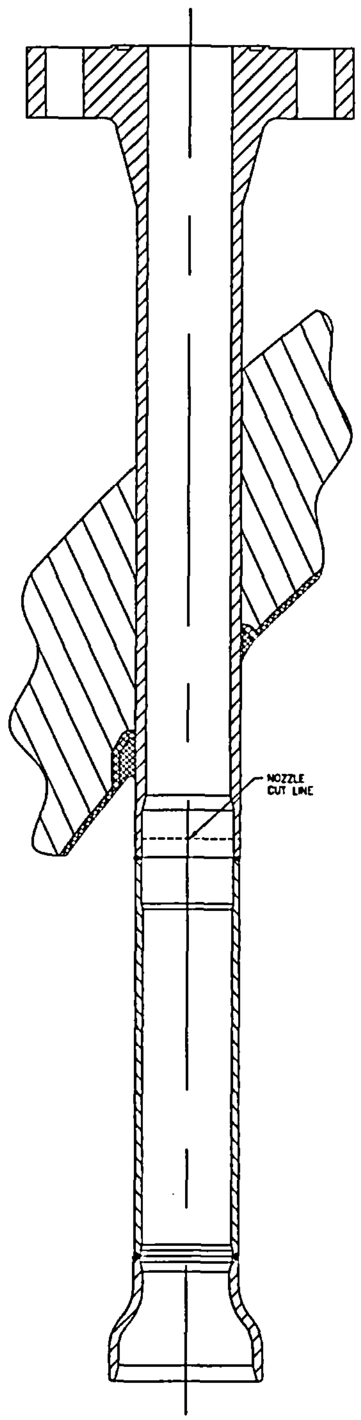
23. The flaw size shown in Table A-1 is used in a sample calculation to illustrate usage of the finite element crack model and to later validate the influence coefficient solution process in Table B-3. The dimensions of the Section III fatigue stress analysis model are used for the postulated flaw size (a_p and b_p) on page 23 since this model is the source of the stresses used in the actual flaw evaluations (Tables 4 through 11).

ATTACHMENT 1

FIGURES OF NOZZLE CONFIGURATION DURING REPAIR PROCESS

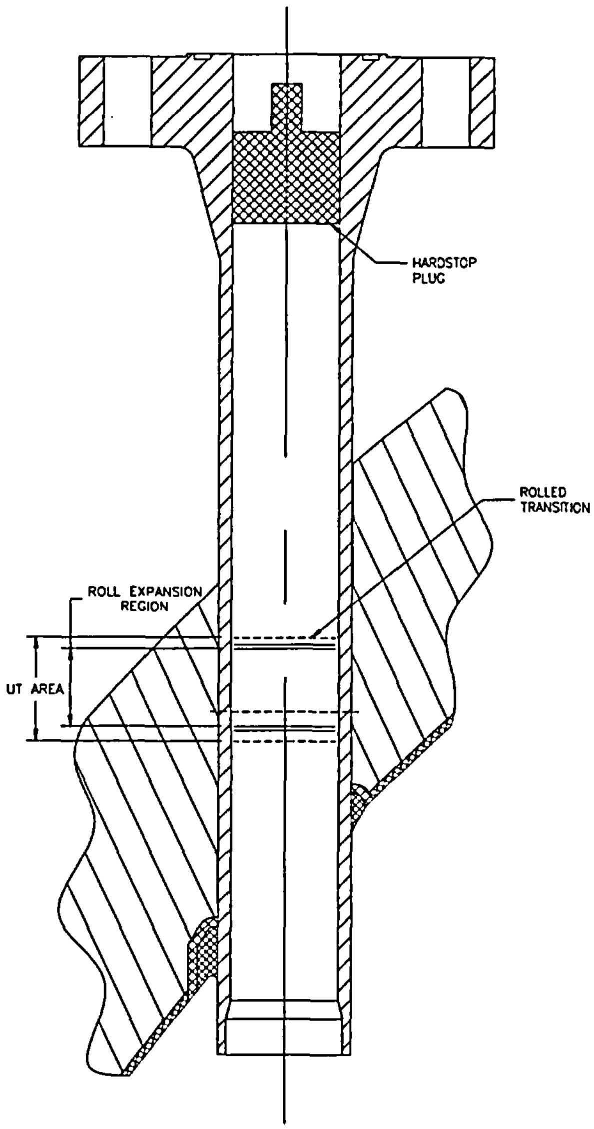
Pages 1 – 7: ICI Configuration
Pages 8 – 14: CRDM Configuration

14 Pages Follow



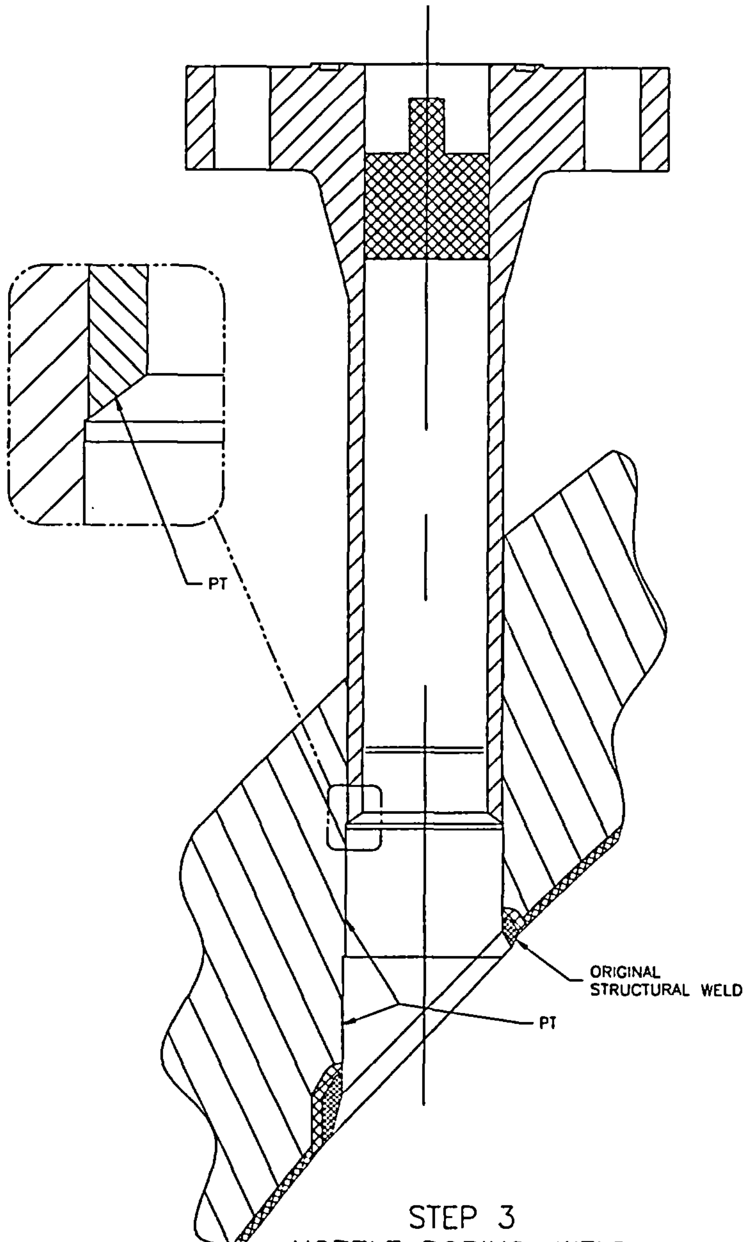
STEP 1
INITIAL NOZZLE CUT

STEP 1: ICI REPAIR



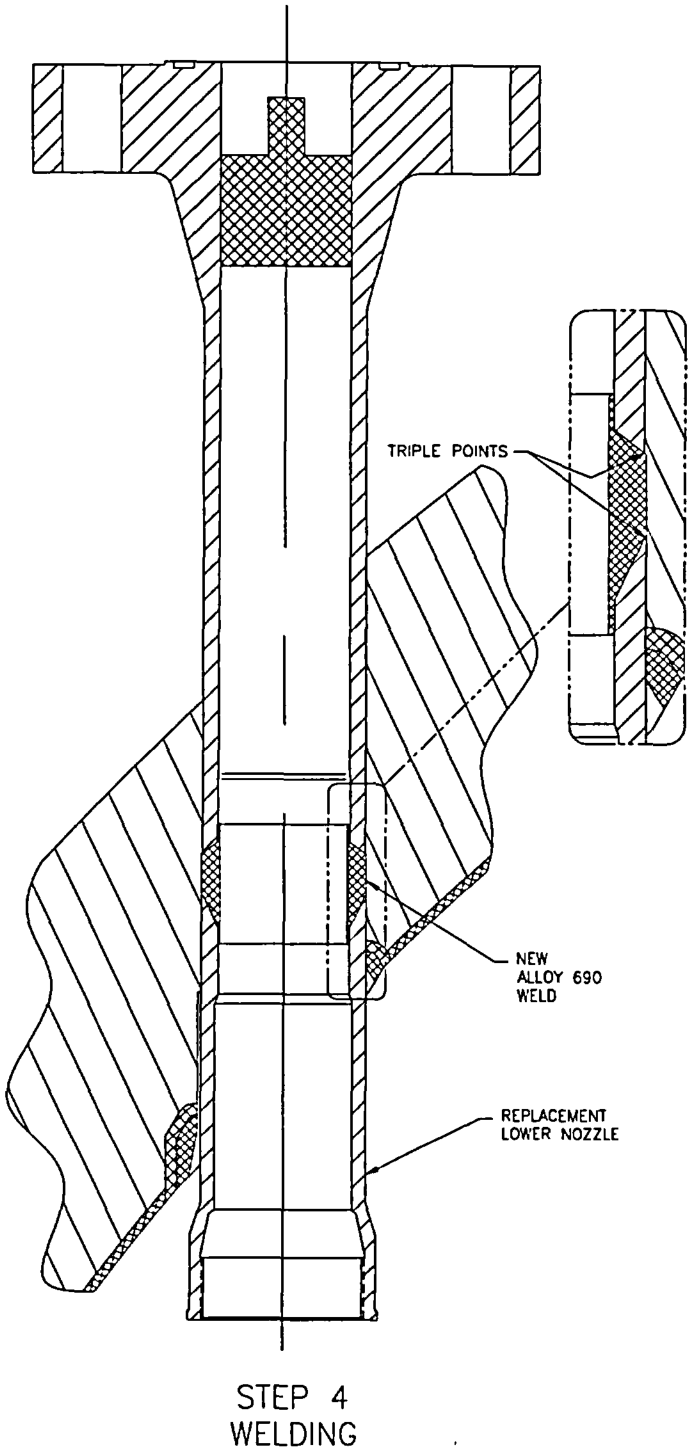
STEP 2
ROLL EXPANSION

STEP 2: ICI REPAIR

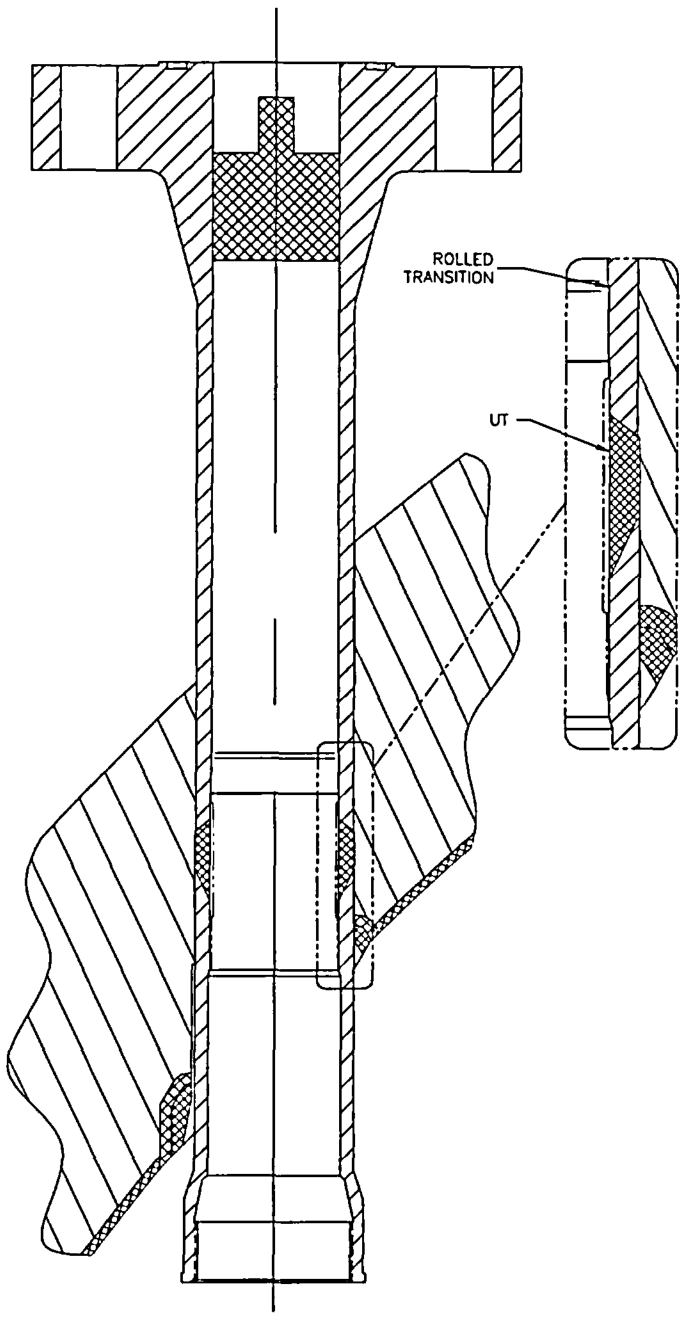


STEP 3
NOZZLE BORING, WELD PREP MACHINING, AND ORIGINAL WELD GRINDING

STEP 3: ICI REPAIR

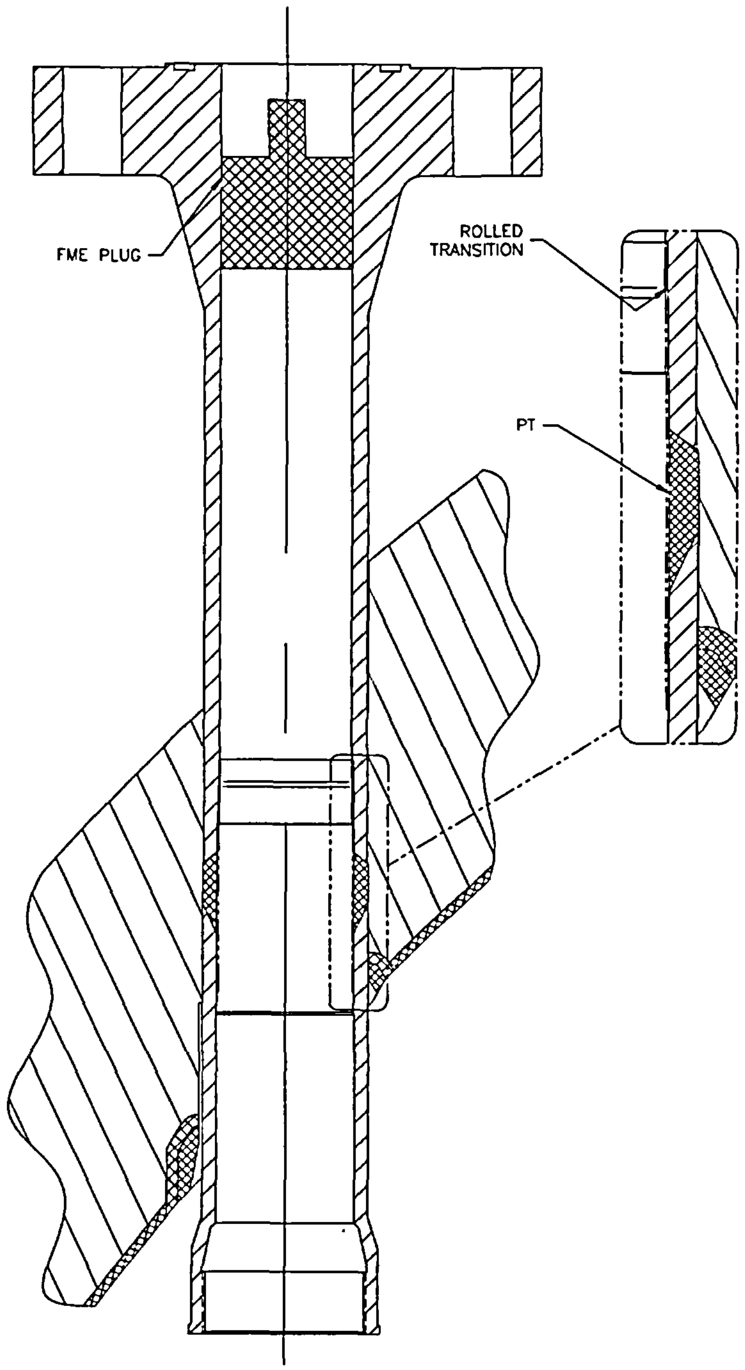


STEP 4: ICI REPAIR



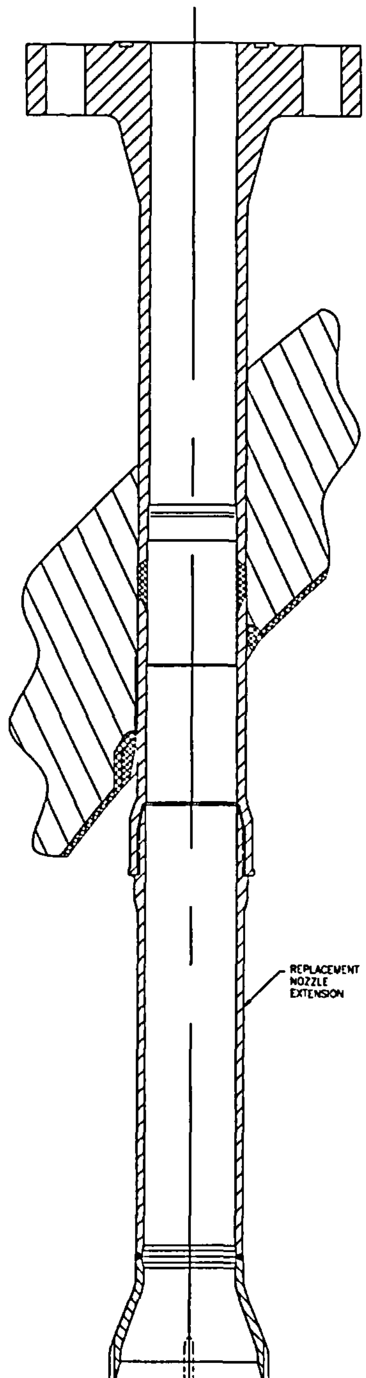
STEP 5
MACHINING AND NDE

STEP 5: ICI REPAIR



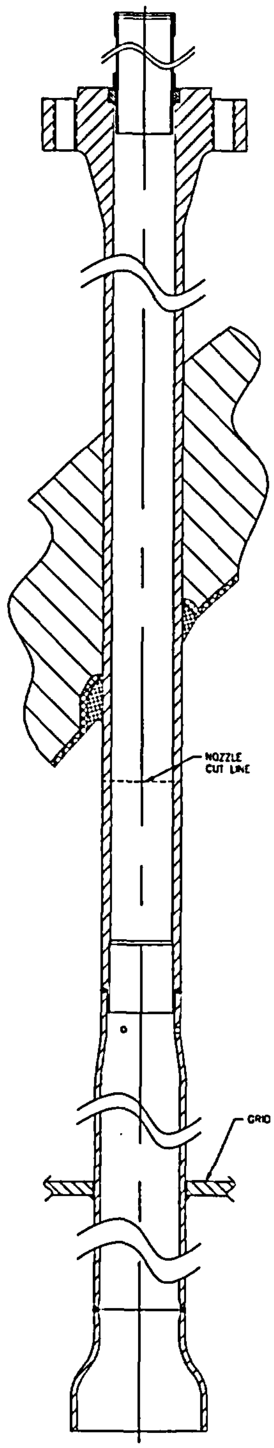
STEP 6
REMEDIATION

STEP 6: ICI REPAIR



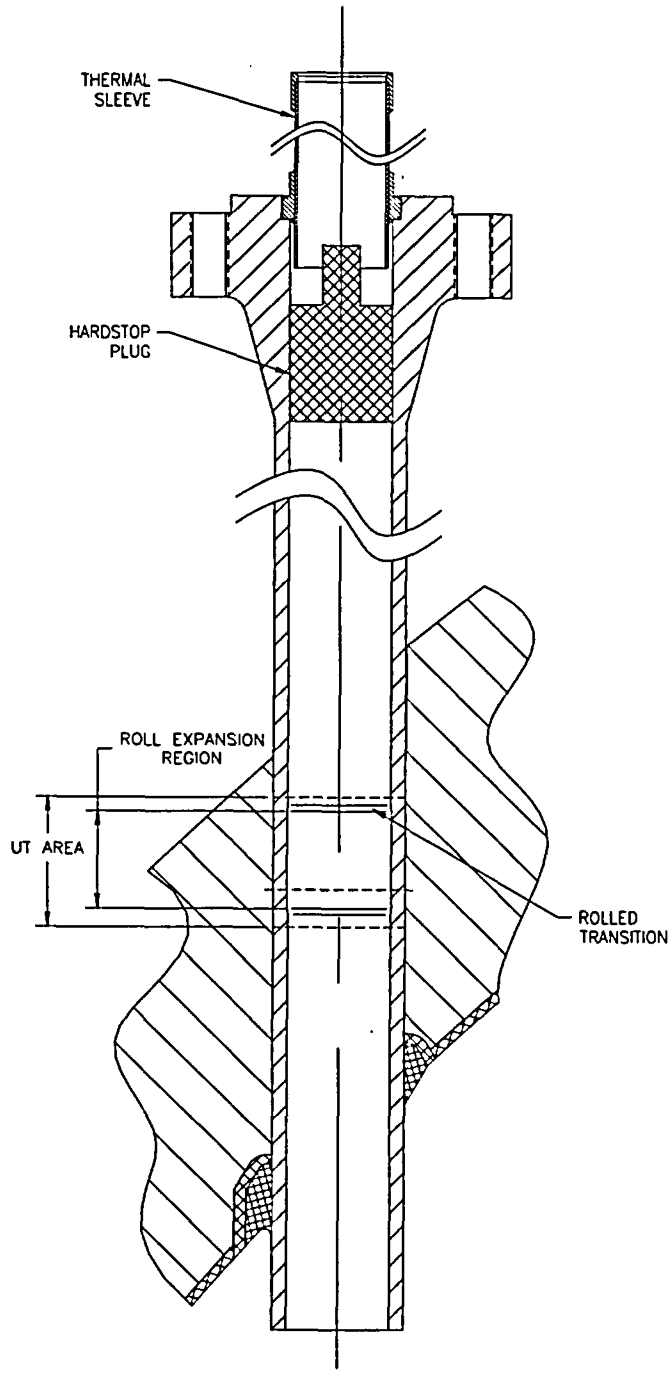
STEP 7
EXTENSION AND
REDUCER INSTALLATION

STEP 7: ICI REPAIR



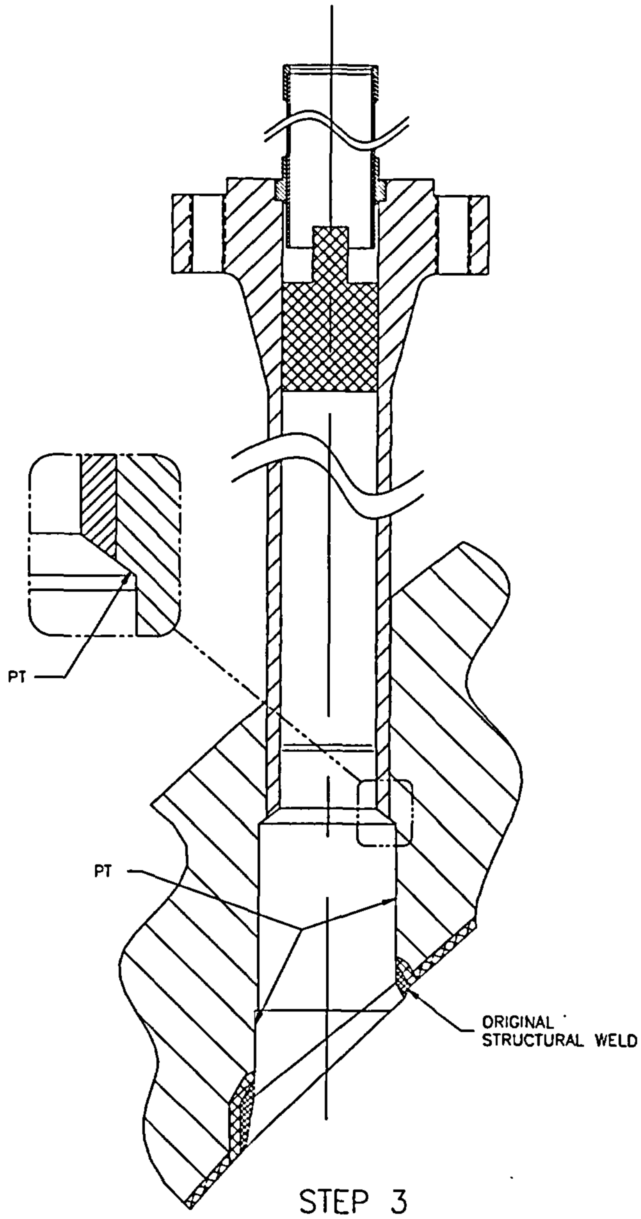
STEP 1
INITIAL NOZZLE CUT

STEP 1: CRDM REPAIR



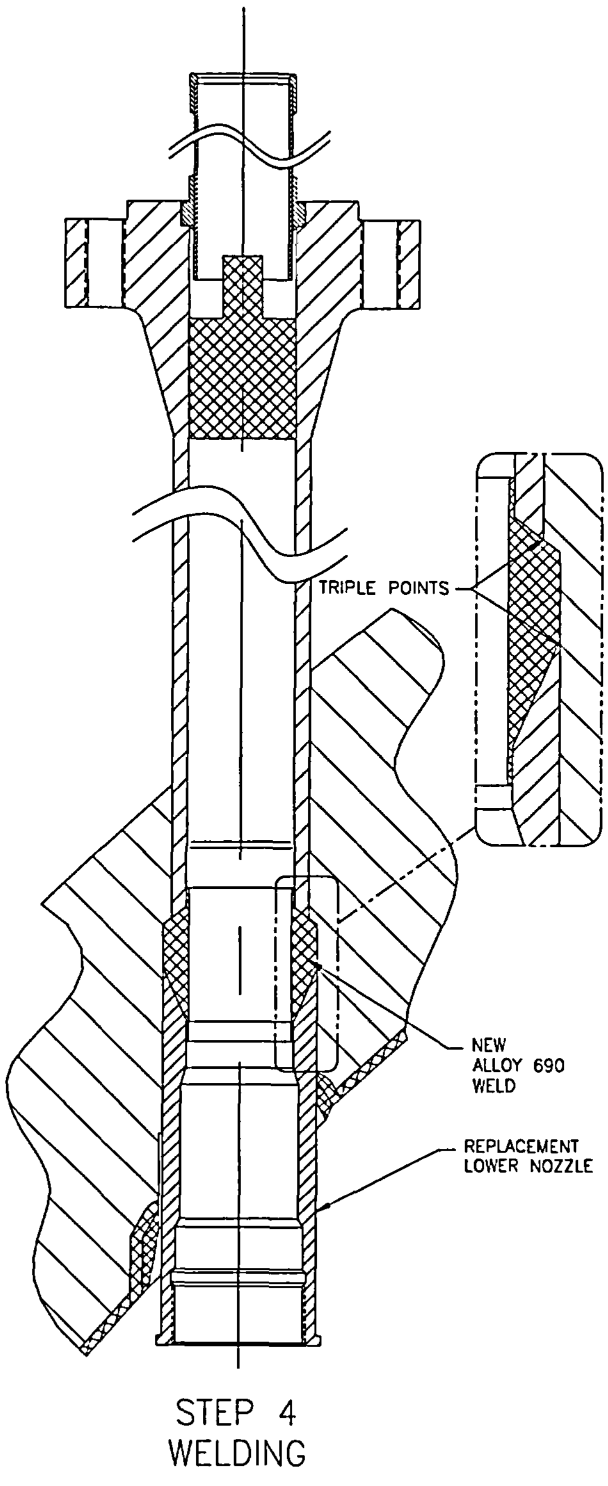
STEP 2
ROLL EXPANSION

STEP 2: CRDM REPAIR

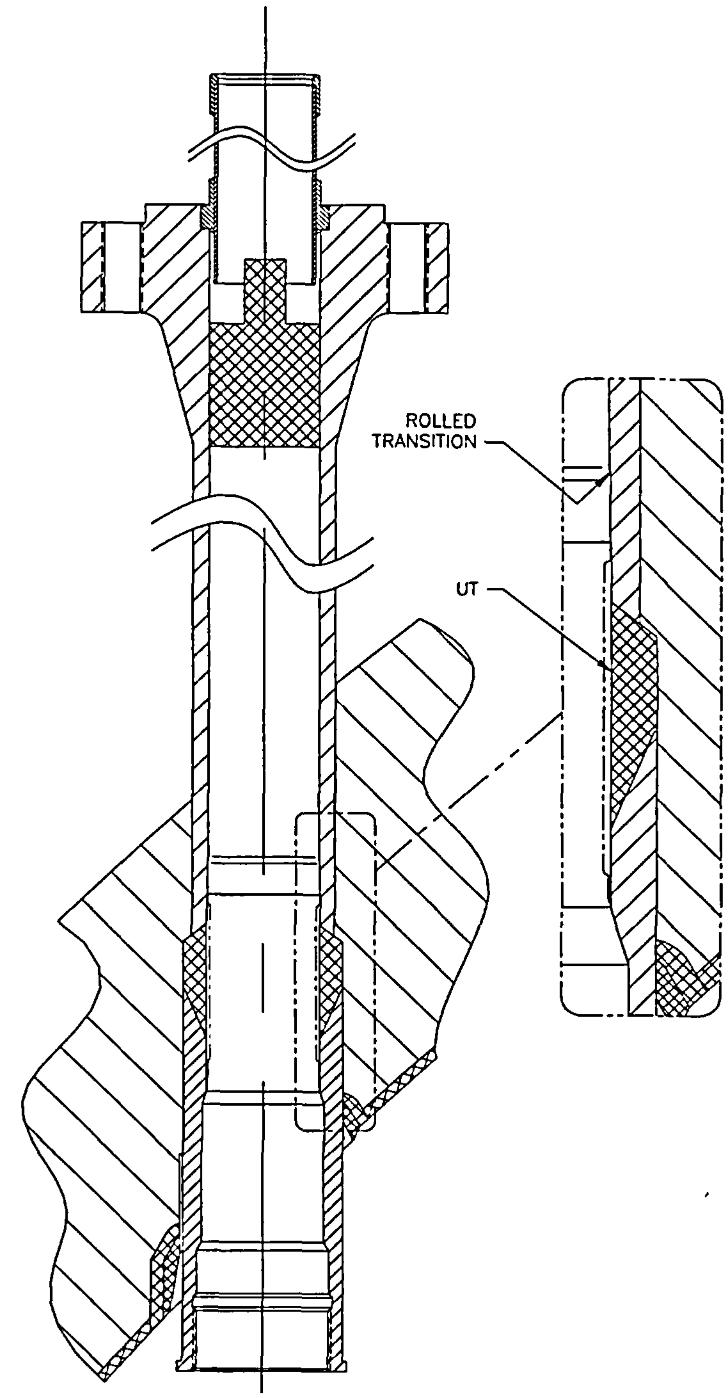


STEP 3
NOZZLE BORING, WELD
PREP MACHINING, AND
ORIGINAL WELD GRINDING

STEP 3: CRDM REPAIR

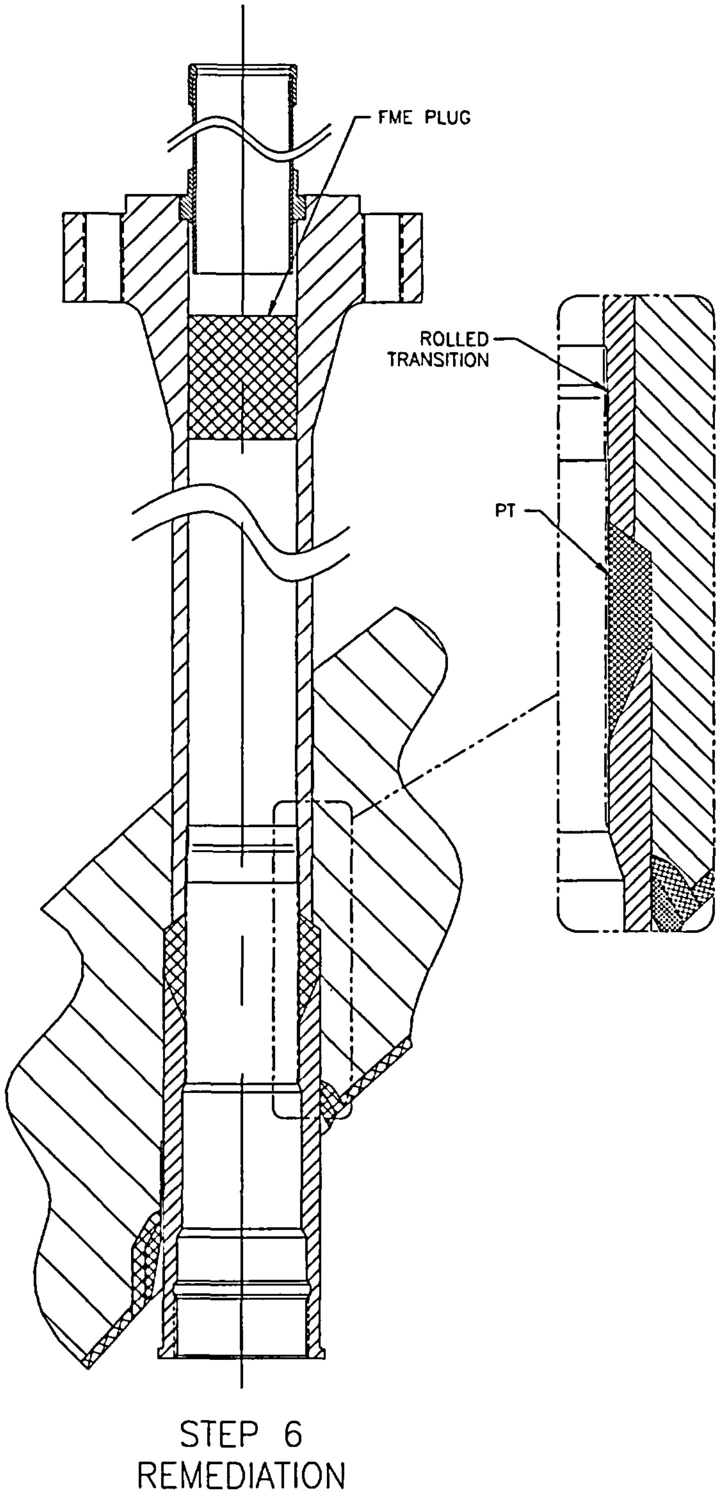


STEP 4: CRDM REPAIR

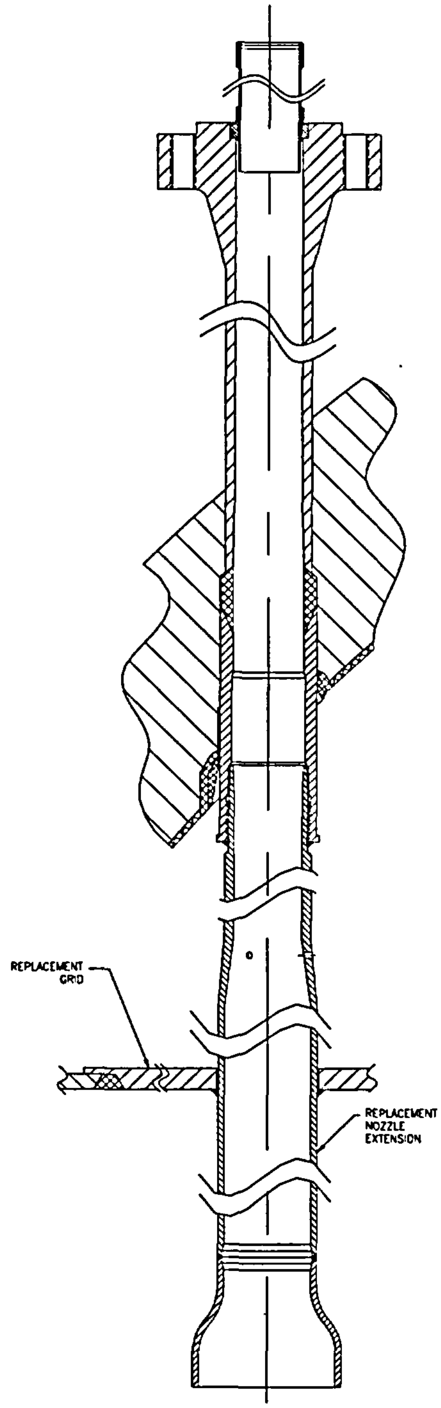


STEP 5
MACHINING AND NDE

STEP 5: CRDM REPAIR



STEP 6: CRDM REPAIR



STEP 7
EXTENSION ASSEMBLY
AND TUBE SUPPORT
PLATE INSTALLATION

STEP 7: CRDM REPAIR