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Calvert Cliffs Nuclear Power Plant

A Member of the Constellation Energy Group

February 7, 2002

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
ASME Section XI Relief Request to Use Alternative Techniques for Reactor Vessel Head Repair

REFERENCE: (a) Letter from Ms. M. Gamberoni (NRC) to Mr. C. H. Cruse (BGE), dated April 5, 2000, Safety Evaluation of Proposed Alternate American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI, 1998 Edition for the Third 10-Year Inspection Interval – Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 (TAC Nos. MA4647 and MA4648

Pursuant to 10 CFR 50.55a(a)(3)(i), Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP) hereby proposes alternatives to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) requirements concerning the Calvert Cliffs Nuclear Power Plant Repair/Replacement of Code Class 1, 2, and 3 components for the Third Ten-Year Inservice Inspection (ISI) interval. Calvert Cliffs Technical Specification 4.0.5 states in part, "Inservice inspection of ASME Code Class 1, 2, and 3 components ... shall be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable Addenda as required by 10 CFR 50, Section 50.55a(g) ...". Paragraph 50.55a(a)(3)(i) allows the use of alternatives to the requirements of Paragraph 50.55a(g), that provide an acceptable level of quality and safety, when authorized by the Director of the Office of Nuclear Reactor Regulation.

The Third Ten-Year ISI Program Plan for Calvert Cliffs Units 1 and 2 meets the requirements of the 1998 Edition, no Addenda of Section XI of the ASME Code (except for Subsections IWE and IWL), as approved by Nuclear Regulatory Commission (NRC) letter dated April 5, 2000 (Reference a). The proposed alternatives to the Code requirements will be used in the event that flaws requiring repair in the reactor vessel closure head (RVCH) penetrations are discovered during inspections.

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RELIEF REQUEST REGARDING IWA-3300 REQUIREMENTS

Section XI, IWA-3300 requires characterization of flaws detected by inservice examination. Following the repair of the control element drive mechanism (CEDM) nozzles, it is assumed that flaws will remain in the original CEDM nozzle to RVCH J-groove weld. During the repair process, CCNPP will remove portions of the original J-groove weld to limit the size of the flaws that remain. In lieu of fully characterizing the existing flaws, CCNPP proposes to utilize worst-case assumptions to conservatively estimate the flaw extent and orientation. The detailed relief request and the justification are provided in Attachment (1).

RELIEF REQUEST TO USE MODIFIED METHODOLOGY OF ASME, SECTION XI CODE CASE N-638

Section XI Code Case N-638 provides an ambient temperature temper bead repair methodology that is an alternative to the preheat and post-weld heat soak requirements of Section XI IWA-4633.2(d) and IWA-4610(a). Calvert Cliffs Nuclear Power Plant plans to perform RVCH penetrations repairs by welding the reactor pressure vessel (RPV) head (P-No. 3 base material) and CEDM nozzle (P-No. 43 base material) with filler material F-No. 43. The Code Case N-638 methodology was developed to repair full penetration RPV welds. The application for Calvert Cliffs involves making new partial penetration welds in the RVCH; hence, some of the Code Case N-638 methodology requirements either do not apply or require substitution of equivalent requirements applicable to partial penetration welds. Therefore, CCNPP is proposing a modified methodology of Code Case N-638, as outlined in Attachment (2), as an alternative to the Code requirement.

SAFETY COMMITTEE REVIEW

The proposed relief request has been reviewed by our Plant Operations and Safety Review Committee, and they have concluded that the proposed alternatives provide an acceptable level of quality and safety.

SCHEDULE

In accordance with the commitment we made in response to NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," we will be performing RPV head inspections during the next refueling outage (currently scheduled to begin in February 2002 for Unit 1 and February 2003 for Unit 2). We request that the NRC review and approve our proposed alternative for use during these outages.

Should you have questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

CHC/GT/bjd

Attachments: (1) Relief Request Regarding IWA-3300 Requirements to Support Reactor Vessel Closure Head Repair
(2) Relief Request To Use Modified Methodology of ASME, Section XI Code Case N-638 to Support Reactor Vessel Closure Head Repair

cc: R. S. Fleishman, Esquire
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Director, Project Directorate I-1, NRC
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ATTACHMENT (1)

RELIEF REQUEST REGARDING IWA-3300

REQUIREMENTS TO SUPPORT

REACTOR VESSEL CLOSURE HEAD REPAIR

Calvert Cliffs Nuclear Power Plant, Inc.
February 7, 2002

ATTACHMENT (1)

RELIEF REQUEST REGARDING IWA-3300 REQUIREMENTS TO SUPPORT REACTOR VESSEL CLOSURE HEAD REPAIR

COMPONENT FOR WHICH RELIEF IS REQUESTED:

Reactor Vessel Closure Head (RVCH) Penetration Welds, American Society of Mechanical Engineers (ASME) Class 1.

CODE REQUIREMENTS FOR WHICH RELIEF IS REQUESTED:

The 1998 Edition no Addenda of ASME Section XI IWA-4611.1(a) requires in part that "Defects shall be removed or reduced in size in accordance with this Paragraph." Furthermore, IWA-4611.l(a) allows that "... the defect removal area and any remaining portion of the flaw may be evaluated and the component accepted in accordance with the appropriate flaw evaluation provisions of Section XI or the design provisions of the Owner's Requirements and either the Construction Code or Section III."

The 1998 Edition no Addenda of ASME Section XI IWA-3300 requires characterization of flaws detected by inservice examination.

PROPOSED ALTERNATIVE:

Following the repair of the control element drive mechanism (CEDM) nozzles, it is assumed that flaws will remain in the original CEDM nozzle to RVCH J-groove weld. During the repair process, Calvert Cliffs Nuclear Power Plant (CCNPP) will remove portions of the original J-groove weld to limit the size of the flaws that remain. In lieu of fully characterizing the existing flaws, as required by IWA-3300, CCNPP proposes to utilize worst-case assumptions to conservatively estimate the crack extent and orientation. The postulated crack extent and orientation will then be evaluated versus the flow acceptance criteria in IWB-3600.

SUPPORTING INFORMATION:

Inspections of the RVCH performed in accordance with the Calvert Cliffs response to Nuclear Regulatory Commission Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," may discover small amounts of boron emanating from the CEDM nozzle interface with the outside radius of the RVCH. Supplemental examinations will be performed to confirm the existence of through-wall cracks that may exist in the original J-groove partial penetration welds or in the CEDM nozzle base material at these locations.

Experience gained from the repairs performed manually on the Oconee Unit 1 and Unit 3 (CEDM) nozzles indicated that removal and repair of the defective portions of the original J-groove partial penetration welds were time consuming and radiation dose intensive. The previous repairs indicated that more remote automated repair methods were needed to reduce radiation dose to repair personnel. For the Calvert Cliffs repairs, a remote semi-automated repair method is planned for each nozzle requiring repair. Using a remote tool, each nozzle requiring repair will first receive a roll expansion into the RVCH base material to ensure that the nozzle will not move during subsequent repair operations. Second, a semi-automated machining tool, from underneath the RVCH, will remove the lower portion of the nozzle to a depth above the existing J-groove partial penetration weld. This operation will sever the existing J-groove partial penetration weld from the CEDM nozzle. Third, a chamfer will be machined into the end of the CEDM nozzle in preparation for the repair weld. Fourth, the original J-groove weld will be chamfered to assure the remaining weld metal is thinner than the maximum allowable flaw size. Finally, a semi-automated weld tool, utilizing the machine gas tungsten-arc welding process, will then be used to install a new Alloy 690 pressure boundary weld between the shortened nozzle and the inside bore of the

RVCH base material (See Figures 3 and 4 of Attachment 2). This weld also attaches the replacement CEDM lower nozzle guide funnel to the lower end of the shortened upper portion of the CEDM nozzle.

It is intended, as part of the new repair methodology and to reduce radiation dose to repair personnel, that the original J-groove partial penetration welds will be left in place. These welds will no longer function as pressure boundary CEDM nozzle to RVCH welds. However, the possible existence of flaws in these welds mandates that the flaw growth potential be evaluated.

The requirements of IWA-4611.1 allows two options for determining the disposition of discovered flaws. The subject flaws are either removed as part of the repair process or left as-is and evaluated per the rules of IWB-3000.

The assumptions of IWB-3600 are that the flaws are fully characterized in order to compare the calculated flaw parameters to the acceptance criteria in IWB-3600. However, the original CEDM nozzle to RVCH J-groove weld is extremely difficult to examine ultrasonically (UT) due to the compound curvature and fillet radius. These conditions preclude ultrasonic coupling and control of the sound beam needed to perform flaw sizing with reasonable confidence in the measured flaw dimension. Therefore, it is impractical to, and presently no nondestructive examination technology has been identified that can, characterize the flaw geometry that may exist therein. Not only is the configuration not conducive to UT, but the dissimilar metal interface between the Alloy 600 weld and the low alloy steel RVCH increases the UT difficulty. Therefore, it is not possible to accurately characterize flaw sizes.

As previously discussed, after the boring and removal of the nozzle end, the remaining weld will be chamfered to assure the remaining weld metal is thinner than the maximum allowable flaw size. Since it has been determined that through-wall cracking in the J-groove weld will most likely accompany a leaking CEDM nozzle, it must be assumed that the "as-left" condition of the remaining J-groove weld includes degraded or cracked weld material.

A fracture mechanics evaluation will be performed to determine if degraded J-groove weld material could be left in the RVCH, with no examination to size any flaws that might remain following the repair. Since the hoop stresses in the J-groove weld are generally about two times the axial stress at the same location, the preferential direction for cracking is axial, or radial relative to the nozzle. It will be postulated that a radial flaw in the Alloy 182 weld metal will propagate by primary water stress corrosion cracking (PWSCC) through the weld and butter, to the interface with the low alloy steel head. It is fully expected that such a flaw would then blunt and arrest at the butter-to-head interface. The repair design will specify that the inside corner of the J-groove weld be chamfered.

Crack growth through the Alloy 182 material would tend to relieve the residual stresses in the weld as the crack grew to its final size and blunted. Although residual stresses in the RVCH material are low, it will be assumed that a small flaw could initiate in the low alloy steel RVCH material and grow by fatigue. It will be postulated that a small flaw in the RVCH would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the low alloy steel head by fatigue crack growth under cyclic loading associated with heat-up and cool-down and other applicable transients.

Residual stresses will not be included in the flaw evaluations since it will be demonstrated by analysis that these stresses are compressive in the RVCH low alloy steel base material. Any residual stresses that

remain in the area of the weld following the boring operation would be relieved by such a deep crack, and therefore need not be considered.

Flaw evaluations will be performed for a postulated radial corner crack on the uphill side of the head penetration, where stresses are the highest. Hoop stresses will be used since they are perpendicular to the plane of the crack. Fatigue crack growth, calculated for at least 8 to 10 years of operation, will be small, and the final flaw size will meet the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi$\sqrt{\text{in}}$ for ferritic materials.

Based on analysis, it will be shown that it is acceptable to leave the postulated cracks in the attachment J-groove weld and buttering. Calculations will be performed to show that the remaining flaws within the base material are acceptable for at least 8 to 10 years. The driving mechanism for fatigue crack growth of the base material is heat-up/cool-down cycles and other transients. The fracture mechanics evaluation assumes a radial (with respect to the penetration center line) flaw exists with a length equal to the partial penetration weld depth. Based on industry experience and operating stress levels, there is no reason for service-related flaws to exist in the ferritic material.

These evaluations provide an acceptable level of safety and quality in ensuring that the RVCH remains capable of performing its design function for at least 8 to 10 years with flaws existing in the original J-groove weld.

CONCLUSION:

Removal of the cracks in the existing J-groove partial penetration welds would incur excessive radiation dose for repair personnel. With the installation of the new pressure boundary welds previously described, the original function of the J-groove partial penetration welds is no longer required. It is well understood that the cause of the cracks in the J-groove welds is PWSCC. As shown by industry experience, the low alloy steel of the RVCH impedes crack growth by PWSCC. Calvert Cliffs believes the alternative described will provide an acceptable level of quality and safety when compared to the Code requirements in IWA-3300. Using flaw tolerance techniques, it will be demonstrated that the assumed worst-case crack would not grow to an unacceptable depth into the RVCH low alloy steel. Thus the RVCH can be accepted per the requirements of IWA-4611.1.

ATTACHMENT (2)

RELIEF REQUEST TO USE MODIFIED METHODOLOGY OF ASME, SECTION XI CODE CASE N-638 TO SUPPORT REACTOR VESSEL CLOSURE HEAD REPAIR

Calvert Cliffs Nuclear Power Plant, Inc.
February 7, 2002

ATTACHMENT (2)

RELIEF REQUEST TO USE MODIFIED METHODOLOGY OF ASME, SECTION XI CODE CASE N-638 TO SUPPORT REACTOR VESSEL CLOSURE HEAD REPAIR

COMPONENT FOR WHICH RELIEF IS REQUESTED:

Reactor Vessel Closure Head (RVCH) Penetration Welds, American Society of Mechanical Engineers (ASME) Class 1

CODE REQUIREMENTS FOR WHICH RELIEF IS REQUESTED:

The 1998 Edition no Addenda of ASME Section XI IWA-4600(b) requires that when post-weld heat treatment is not to be performed, the following provisions may be used.

(1) The welding methods of IWA-4620, IWA-4630, or IWA-4640 may be used in lieu of the welding and nondestructive examination (NDE) requirements of the Construction Code or Section III, provided the requirements of IWA-4610 are met.

The 1998 Edition no Addenda of ASME Section XI IWA-4610(a) requires the area to be welded plus a band around the area of at least 1-1/2 times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 350°F for the shielded metal-arc welding process and 300°F for the gas tungsten-arc welding (GTAW) process during welding. The maximum interpass temperature shall be 450°F. Thermocouples and recording instruments shall be used to monitor the process temperatures. Their attachment and removal shall be in accordance with Section III.

PROPOSED ALTERNATIVE:

Section XI Code Case N-638 provides an ambient temperature temper bead repair methodology that is an alternative to the preheat and post-weld heat soak requirements of Section XI IWA-4633.2(d) and IWA-4610(a). Calvert Cliffs Nuclear Power Plant (CCNPP) plans to perform RVCH penetration repairs by welding the RVCH (P-No. 3 base material) and control element drive mechanism (CEDM) nozzle (P-No. 43 base material) with filler material F-No. 43. The Code Case N-638 methodology was developed to repair full penetration reactor pressure vessel welds. The application for Calvert Cliffs involves making new partial penetration welds in the RVCH; hence, some of the Code Case N-638 methodology requirements either do not apply or require substitution of equivalent requirements applicable to partial penetration welds. Therefore, CCNPP is proposing a modified methodology of Code Case N-638, as outlined below, as an alternative to the Code requirement.

The following text has been prepared using Code Case N-638 methodology as a template, with specific criteria applicable to the CEDM nozzle repairs identified and appropriately dispositioned. Clarifications to the Code Case template are made in Italics font.

1.0 GENERAL REQUIREMENTS:

(a) The maximum area of an individual weld based on the finished surface will be less than 100 square inches, and the depth of the weld will not be greater than one-half of the ferritic base metal thickness.

(b) Repair/replacement activities on a dissimilar-metal weld are limited to those along the fusion line of a nonferritic weld to ferritic base material on which 1/8 inch or less of nonferritic weld deposit exists above the original fusion line.

(c) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed provided the depth of repair in the base material does not exceed 3/8 inch.

(d) Prior to welding, the area to be welded and a band around the area of at least 1-1/2 times the component thickness (or 5 inches, whichever is less) will be at least 50°F.

Preheat temperature will be monitored using either TC(s) or contact pyrometer(s) placed at a readily accessible location(s) on the closure head exterior surface and will probably be outside the 5" band.

(e) Welding materials will meet the Owner's Requirements and the Construction Code and Cases specified in the repair/replacement plan. Welding materials will be controlled so that they are identified as acceptable until consumed.

(f) Peening may be used, except on the initial and final layers.

Peening will not be used However, the weldment final surface will be abrasive water jet conditioned following final NDE

2.0 WELDING QUALIFICATIONS:

The welding procedures and the welding operators shall be qualified in accordance with Section IX and the requirements of paragraphs 2.1 and 2.2.

2.1 Procedure Qualification

(a) The base materials for the welding procedure qualification will be the same P-Number and Group Number as the materials to be welded. The materials shall be post-weld heat-treated to at least the time and temperature that was applied to the material being welded.

(b) Consideration will be given to the effects of welding in a pressurized environment. If they exist, they shall be duplicated in the test assembly.

The nozzle repair will not be performed in a pressurized environment. Therefore, this requirement is not applicable.

(c) Consideration will be given to the effects of irradiation on the properties of material, including weld material for applications in the core belt line region of the reactor vessel. Special material requirements in the Design Specification will also apply to the test assembly materials for these applications.

No repair welding will be performed in the core belt line region of the reactor vessel. Therefore, this requirement has been considered, but is not applicable.

(d) The root width and included angle of the cavity in the test assembly will be no greater than the minimum specified for the repair.

(e) The maximum interpass temperature for the first three layers of the test assembly will be 150°F.

(f) The test assembly cavity depth will be at least one-half the depth of the weld to be installed during the repair/replacement activity, and at least 1 inch. The test assembly thickness will be at least twice the test assembly cavity depth. The test assembly will be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity will be at least the test assembly thickness, and at least 6 inches. The qualification test plate will be prepared in accordance with Figure 1.

(g) Ferritic base material for the procedure qualification test will meet the impact test requirements of the Construction Code and Owner's Requirements. If such requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material at or below the lowest service temperature of the item to be repaired. The location and orientation of the test specimens shall be similar to those required in subparagraph (i), but shall be in the base metal.

(h) Charpy V-notch tests of the ferritic weld metal of the procedure qualification shall meet the requirements as determined in subparagraph (g) above.

No ferritic weld material will be used. Therefore, this requirement is not applicable.

(i) Charpy V notch tests of the ferritic heat-affected zone (HAZ) will be performed at the same temperature as the base metal test of subparagraph (g) above. Number, location, and orientation of test will be will be as follows:

1. Specimens will be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The test coupons for HAZ impact specimens will be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimens will be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. When the material thickness permits, the axis of a specimen will be inclined to allow the root of the notch to be aligned parallel to the fusion line.

2. If the test material is in the form of a plate or a forging, the axis of the weld will be oriented parallel to the principal direction of rolling or forging.

3. The Charpy V-notch test will be performed in accordance with SA-370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products. Specimens will be in accordance with SA-370, Figure 11, Type A. The test will consist of a set of three full-size 10 mm x 10 mm specimens. The lateral expansion, percent shear, absorbed energy, test temperature, orientation and location of all test specimens will be reported in the Procedure Qualification Record.

(j) The average values of the three HAZ impact tests will be equal to or greater than the average values of the three unaffected base metal tests.

2.2 Performance Qualification

Welding operators will be qualified in accordance with ASME Section IX.

3.0 WELDING PROCEDURE REQUIREMENTS:

The welding procedure shall include the following requirements:

(a) The weld metal will be deposited by the automatic or machine GTAW process.

The machine GTAW process will be used.

(b) Dissimilar metal welds shall be made using A-No. 8 weld metal (QW-442) for P-No. 8 to P-No. 1, 3, or 12(A, B, or C) weld joints or F-No. 43 weld metal (QW-432) for P-No. 8 or 43 to P-No. 1, 3, or 12(A, B, or C) weld joints.

Dissimilar metal welds will be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints. ERNiCrFe-7 filler metal is considered F-No. 43 in Code Case 2142-1.

(c) The area to be welded will be buttered with a deposit of at least three layers to achieve at least 1/8 inch overlay thickness as shown in Figure 2, steps 1 through 3, with the heat input for each layer controlled to within ± 10% of that used in the procedure qualification test. Particular care will be taken in placement of the weld layers at the weld toe area of ferritic material to ensure that the HAZ and ferritic weld metal are tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification. For similar-metal welding, the completed weld shall have at least one layer of weld reinforcement deposited. This reinforcement shall be removed by mechanical means, so that the finished surface is essentially flush with the surface surrounding the weld (Figure 3).

The final two sentences, including Figure 3 (in Code Case N-638) of the paragraph above are not applicable since no similar-metal welding will be performed.

(d) The maximum interpass temperature for field applications will be 350°F regardless of the interpass temperature during qualification.

The maximum interpass temperature will be 350°F, verified by calculation rather than thermocouple measurement, regardless of the interpass temperature during qualification.

(e) Particular care will 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.

4.0 EXAMINATION

(a) Prior to welding, a surface examination will be performed on the area to be welded.

(b) The final weld surface and the band around the area defined in paragraph 1.0(d) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for a least 48 hours. The ultrasonic examination shall be in accordance with Appendix I.

The final weld will be examined using the liquid penetrant and ultrasonic examination methods. The band around the area defined in paragraph 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld. Liquid penetrant (PT) examination coverage will include the final weld surface and base metal at least 1/2 inch around the nozzle. Ultrasonic examination (UT) will include the base metal 1/2 inch above the weld and the weld surface.

Liquid penetrant examination coverage is shown in Figures 5 and 6. Ultrasonic examination coverage is shown in Figures 7 through 12 for the various ultrasonic scans.

(c) Areas from which weld-attached thermocouples have been removed shall be ground and examined using a liquid penetrant examination method.

Thermocouples will not be used to monitor interpass temperature. Contact pyrometer(s) or TC(s) will be used to monitor preheat temperature.

(d) Nondestructive examination personnel will be qualified in accordance with IWA-2300.

Nondestructive examination personnel will be qualified in accordance with IWA-2300 or NB-5500.

(e) Surface examination acceptance criteria shall be in accordance with NB-5340 or NB-5350, as applicable. Ultrasonic examination acceptance shall be in accordance with IWB-3000. Additional acceptance criteria may be specified by the Owner to account for differences in weld configuration.

The surface examination acceptance criteria will be in accordance with NB-5350 of the 1992 Edition of ASME Section III. The ultrasonic examination acceptance criteria will be in accordance with NB-5330 of the 1992 Edition of ASME Section III. The 1992 Edition of ASME Section III is used in accordance with Code Case N-416-1. Code Case N-416-1 is approved in NRC Regulatory Guide 1.147, Revision 12.

5.0 DOCUMENTATION

Repairs will be documented on Form NIS-2.

Justification for the Granting of Relief:

The repair process will consist of the following activities:

(a) Using a remote tool from below the RVCH, each nozzle requiring repair will first receive a roll expansion into the RVCH base material to insure that the nozzle will not move during the repair operations.

(b) A semi-automated machining tool, operating underneath the RVCH, will remove the entire lower portion of the CEDM nozzle to a depth above the existing J-groove partial penetration weld. The machining tool will also perform the CEDM nozzle repair weld preparation. The operation will sever the existing J-groove partial penetration weld from the CEDM nozzles.

(c) The machined surfaces will be cleaned, and then examined using PT.

(d) The repair weld will be performed with a remotely operated machine GTAW weld head, using the ambient temperature temper bead process to install the new ERNiCrFe-7 (Alloy 52) pressure boundary weld between the shortened nozzle and the inside bore of the RVCH base material, with 50°F minimum preheat temperature.

(e) The final weld face will be machined and/or ground.

(f) The final weld will be liquid penetrant and ultrasonically examined prior to the abrasive water jet conditioning, to preclude masking by the abrasive water jet process.

(g) The final inside diameter surface of the CEDM nozzle near the new weld and the new weld will then be conditioned by abrasive water-jet conditioning to create a final surface that is in compression, to produce optimum resistance to primary water stress corrosion cracking.

The CEDM nozzle repair configuration described above is illustrated in Figures 3 and 4.

Welding Process:

Quality temper bead welds, without preheat and post-weld heat soak, can be made based on welding procedure qualification test data derived from the machine GTAW ambient temperature temper bead welding process. The proposed alternative repair technique has been demonstrated as an acceptable method for performing pressure vessel repairs. The ambient temperature temper bead technique has been approved by the NRC as having an acceptable level of quality and safety and was successfully used at several sites (Duane Arnold, Nine Mile Point, Fitzpatrick, TMI-1, CR-3, Surry 1, and Oconee 3).

Results of procedure qualification work undertaken to date indicate that the process produces sound and tough welds. For instance, typical tensile test results have been ductile breaks in the weld metal.

As shown below, Procedure Qualification Record (FRA-ANP PQR 7164) using P-No. 3, Group No. 3 base material exhibited improved Charpy V-notch properties in the HAZ from both absorbed energy, lateral expansion, and shear fracture perspectives, compared to the unaffected base material.

PQR 7164	Unaffected Base Material	HAZ
50°F absorbed energy (ft-lbs)	69, 55, 77	109, 98, 141
50°F lateral expansion (mils)	50, 39, 51	59, 50, 56
50°F shear fracture (%)	30, 25, 30	40, 40, 65
80°F absorbed energy (ft-lbs)	78, 83, 89	189, 165, 127
80°F lateral expansion (mils)	55, 55, 63	75, 69, 60
80°F shear fracture (%)	35, 35, 55	100, 90, 80

The absorbed energy, lateral expansion, and percent shear were significantly greater for the HAZ than the unaffected base material at both test temperatures. It is clear from these results that the machine GTAW temper bead process has the capability of producing acceptable repair welds.

Based on FRA-ANP prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding, quality temper bead welds can be performed with 50°F minimum preheat and no post-weld heat soak. Additional FRA-ANP qualifications were performed on thc same P-3 Group-3 base material using the same filler material (Alloy 52, AWS Class ERNiCrFe-7), with similar low heat input controls as will be used in the repairs. Also, the qualifications did not include post-weld heat soak. The qualification of the ambient temperature temper bead welding process demonstrates that the proposed alternative provides an acceptable level of quality and safety. The methodology of Code Case N-638, on which the alternative welding process has been based, was approved by ASME on September 24, 1999.

Monitoring of Interpass Temperature:

Access to the repair area is limited and does not allow the monitoring of interpass temperature with thermocouples at the repair area. In lieu of using thermocouples for interpass temperature measurements, calculations show that the maximum interpass temperature will never be exceeded based on a maximum allowable low welding heat input, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation supports the conclusion that using the maximum heat input through the third layer of the weld, the interpass temperature returns to near ambient temperature. Heat input beyond the third layer will not have a metallurgical affect on the low alloy steel HAZ.

The calculation is based on a typical inter-bead time interval of five minutes. The five minute inter-bead interval is based on:

1) the time required to explore the previous weld deposit with the two remote cameras housed in the weld head,

2) time to shift the starting location of the next weld bead circumferentially away from the end of the previous weld-bead, and

3) time to shift the starting location of the next bead axially to insure a 50% weld bead overlap required to properly execute the temper bead technique.

A welding mock-up on the full-size Midland RVCH, which is similar to the Calvert Cliffs RVCH, was used to demonstrate the welding technique described herein. During the mock-up, thermocouples were placed to monitor the temperature of the head during welding. Thermocouples were placed on the outside surface of the closure head within a 5-inch band surrounding the (CEDM) nozzle. Three other thermocouples were placed on the closure head inside surface. One of the three thermocouples was placed 1-1/2 inches from the (CEDM) nozzle penetration on the lower hillside. The other inside surface thermocouples were placed at the edge of the 5-inch band surrounding the (CEDM) nozzle, one on the lower hillside, the second on the upper hillside. During the mock-up, all thermocouples fluctuated less than 15°F throughout the welding cycle. Based on past experience, it is believed that the temperature fluctuation was due more to the resistance heating temperature variations than the low heat input from the welding process. For the Midland RVCH mock-up application 300°F minimum preheat temperature was used. Therefore, for ambient temperature conditions used for this repair, maintenance of the 350°F maximum interpass temperature will certainly not be a concern.

Monitoring of Preheat Temperature:

Preheat temperature will be monitored using either TC(s) or contact pyrometer(s) placed at a readily accessible location(s) on the closure head exterior surface and probably outside the 5" band. The closure head preheat temperature will be essentially the same as the reactor building ambient temperature, therefore closure head preheat temperature monitoring in the weld region is unnecessary and only results in additional personnel dose associated with TC placement and removal.

Nondestructive Examinations:

Code Case N-416-1 is used for pressure testing the repair weld. Code Case N-416-1, which is approved in NRC Regulatory Guide 1.147, Revision 12, allows a system leakage test in lieu of a hydrostatic test as required by ASME Section XI provided the weld receives NDE in accordance with ASME Section III, 1992 Edition. Paragraph NB-5245 of ASME Section III requires incremental and final surface

examination of partial penetration welds. Due to the welding layer deposition sequence (i.e., each layer is deposited parallel to the penetration centerline), the specific requirements of NB-5245 cannot be met. The Construction Code requirement for progressive surface examination was because volumetric examination is not practical for conventional partial penetration weld configurations. In this case ultrasonic examination and a final surface examination can be performed.

The band around the area defined in paragraph 1.0(d) is inaccessible for NDE due to the physical configuration and location of the partial penetration weld. The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. The exposed ferritic steel portion of the CEDM penetration plus the weld preparation bevel on the lower end of the remaining portion of the CEDM nozzle as well as the adjacent portion of the CEDM nozzle inside diameter immediately above the weld preparation is liquid penetrant examined prior to welding (See Figure 5). This examination provides assurance that no flaws exist on the surfaces in the bore in the region to be welded. The final examination of the new weld repair and immediate surrounding area 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. Liquid penetrant coverage is shown in Figure 6. Ultrasonic examination will be performed scanning from the ID surface of the weld and adjacent portion of the CEDM nozzle bore. The UT is qualified to detect flaws in the repair weld and base metal interface in the repair region, to the maximum practical extent.

The UT transducers and delivery tooling are capable of scanning from cylindrical surfaces with inside diameters near 2.75 inches. The scanning is performed using 0° L-wave, 45° L-wave, and 70° L-wave transducers to scan the area of interest. The UT coverage volumes are shown in Figures 7 through 12 for the various scans.

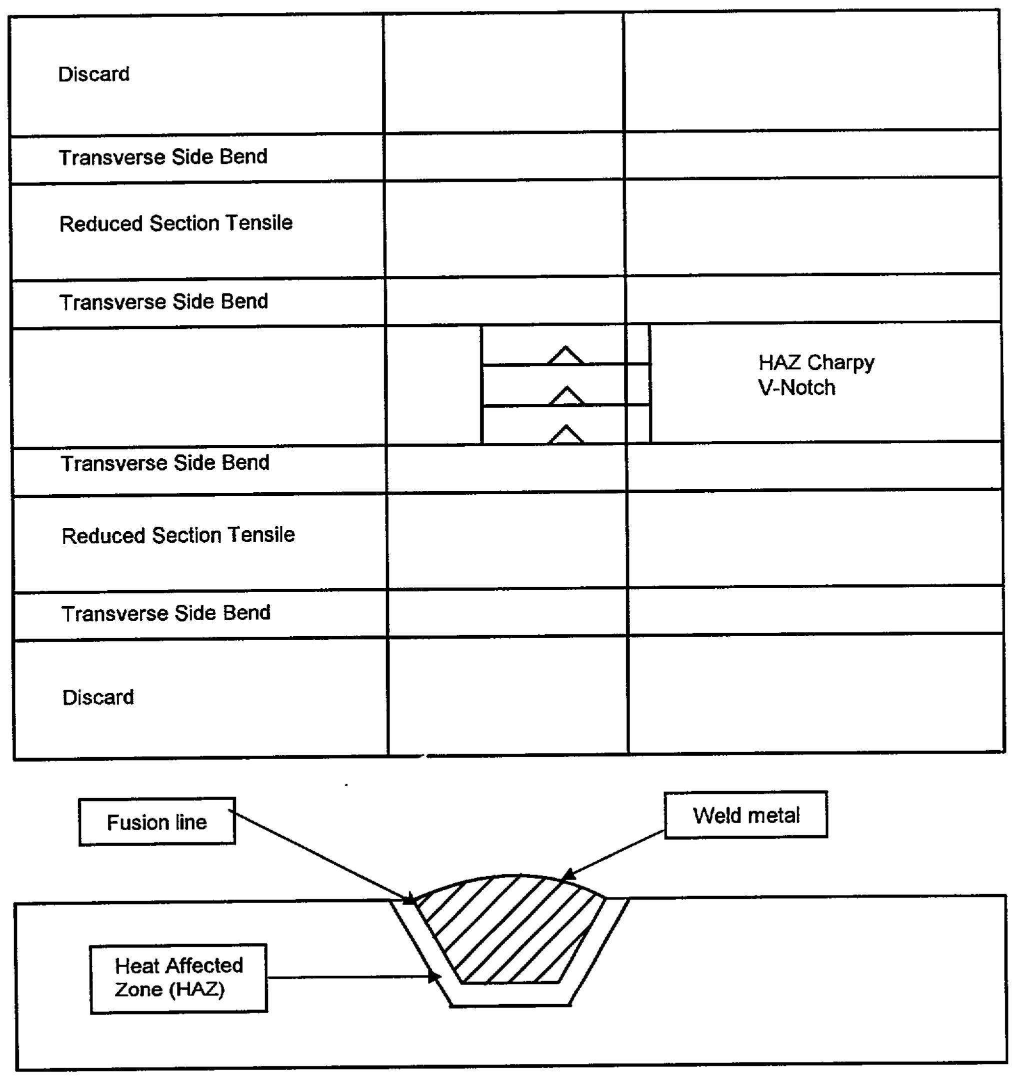
SUPPORTING INFORMATION:

Recent experience gained from the performance of manual repairs to other plants' (CEDM) nozzles indicated that more remote automated repair methods were needed to reduce radiation dose to repair personnel and still provide acceptable levels of quality and safety. Since Calvert Cliffs recognizes the importance of as low as reasonably achievable principles, this remote repair method has been developed for the possibility of leaking nozzles at Calvert Cliffs.

This approach for repair of leaking CEDM nozzles will significantly reduce radiation dose to repair personnel while still maintaining acceptable levels of quality and safety. The total radiation dose for the proposed remote repair method is projected at 7 to 8 Rem per nozzle. In contrast, using manual repair methods would result in a total radiation dose of approximately 30 Rem.

CONCLUSION:

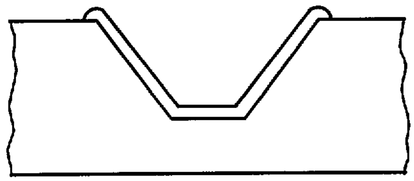
Unacceptable flaws detected during inspections of the Calvert Cliffs CEDM nozzles will be repaired using the machine GTAW ambient temperature temper bead technique, with a 50°F minimum preheat and no post-weld heat treatment as described in this relief request. This alternative welding process provides an equivalent acceptable level of quality and safety to the temper bead welding process described in the 1998 Edition no Addenda of ASME Section XI.



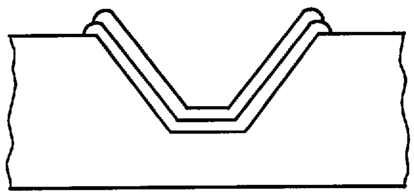
GENERAL NOTE: Base metal Charpy impact specimens are not shown. This figure illustrates a similar-metal weld.

QUALIFICATION TEST PLATE

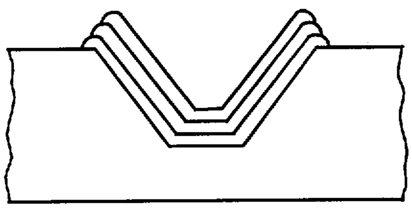
Figure 1



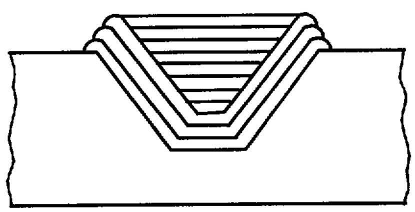
Step 1: Deposit layer one with first layer weld parameters used in qualification.



Step 2: Deposit layer two with second layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the second layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.



Step 3: Deposit layer three with third layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the third layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.



Step 4: Subsequent layers to be deposited as qualified, with heat input less than or equal to that qualified in the test assembly. NOTE: Particular care shall be taken in application of the fill layers to preserve the temper of the weld metal and HAZ

GENERAL NOTE: The illustration above is for similar-metal welding using a ferritic filler material. For dissimilar-metal welding, only the ferritic base metal is required to be welded using steps 1 through 3 of the temperbead welding technique.

AUTOMATIC OR MACHINE (GTAW) TEMPERBEAD WELDING

Figure 2

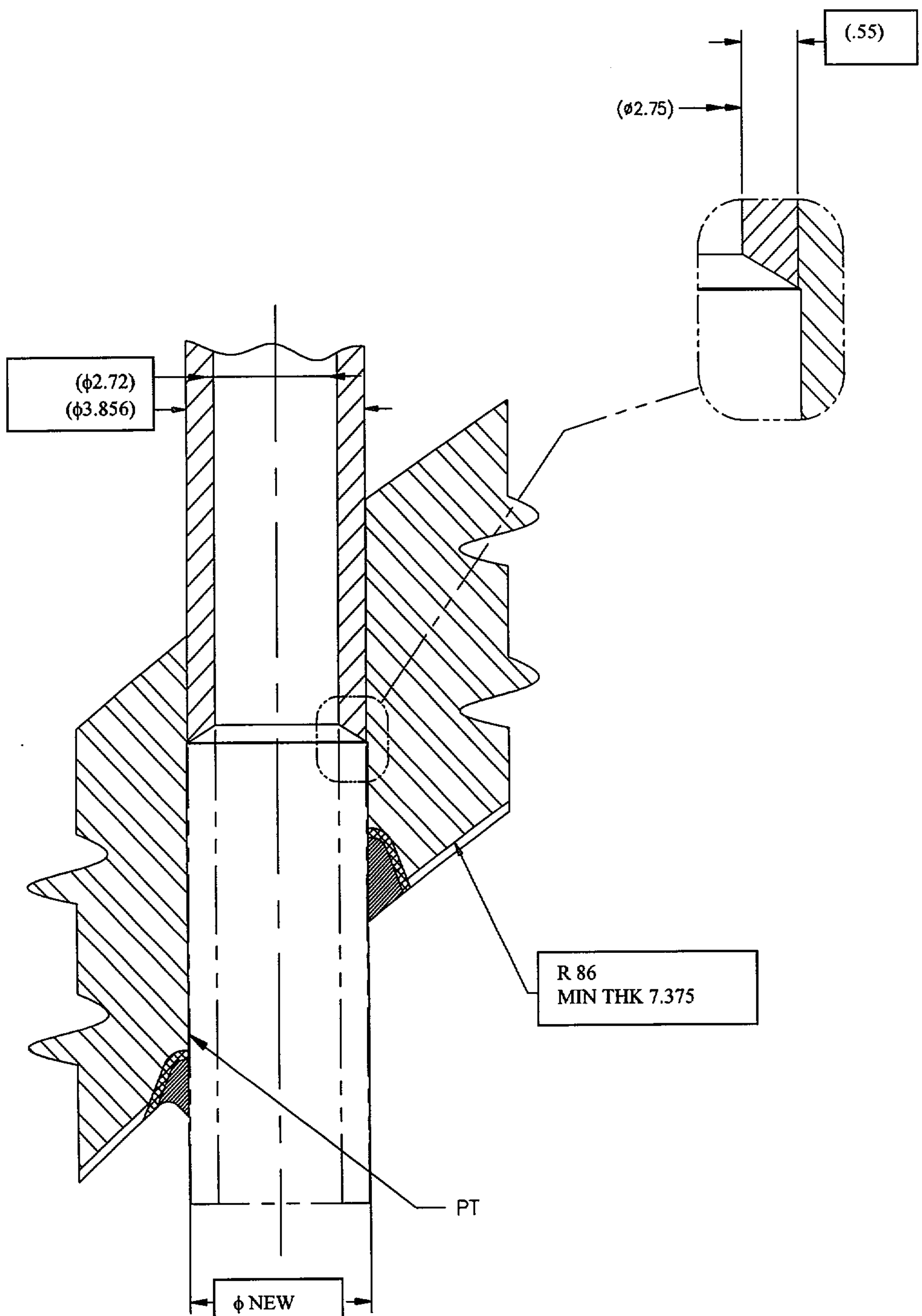


Figure 3
CEDM Temper Bead Weld Repair
CEDM Penetration Bore Machining

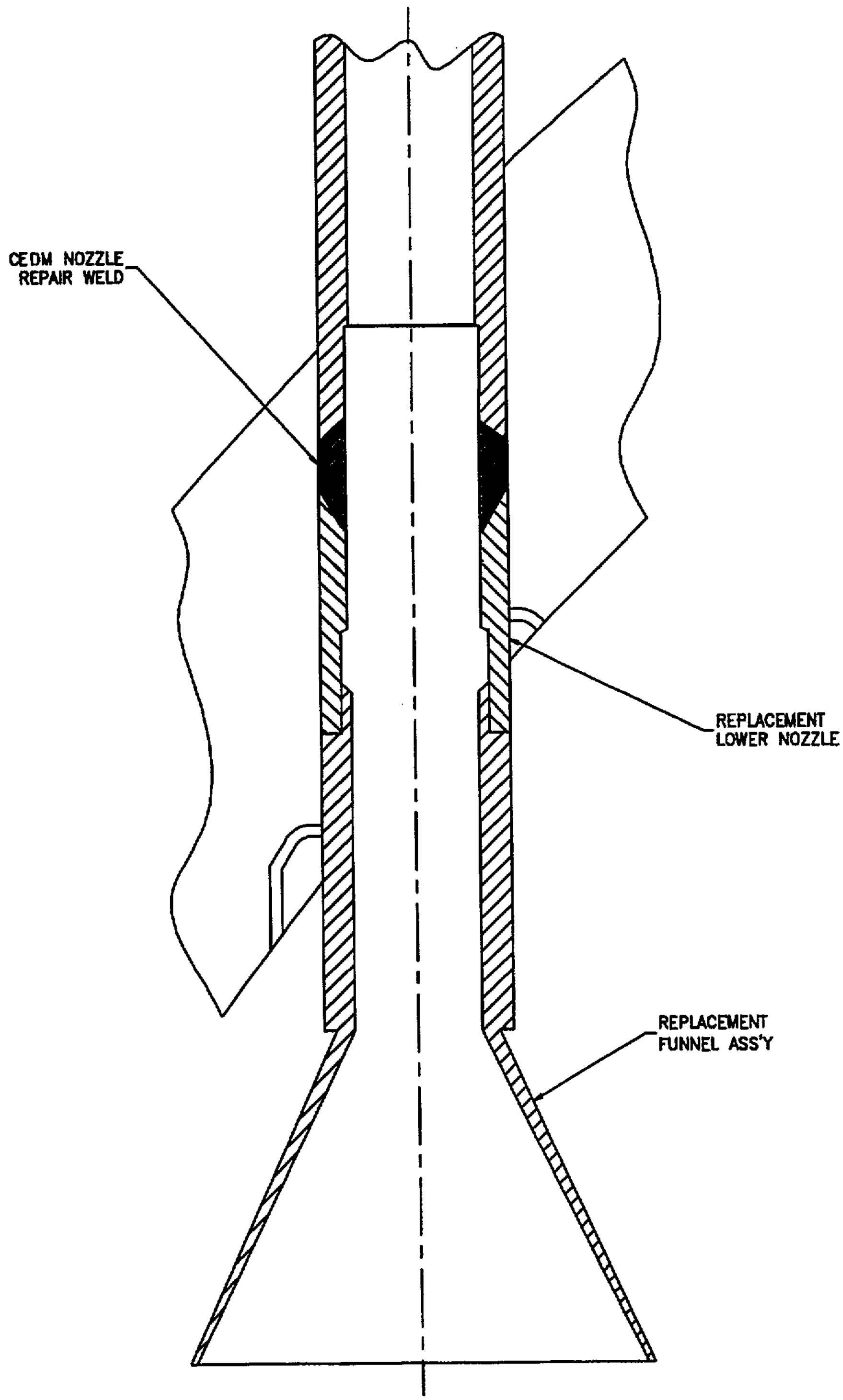


Figure 4
CEDM Temper Bead Weld Repair
New CEDM Pressure Boundary Weld

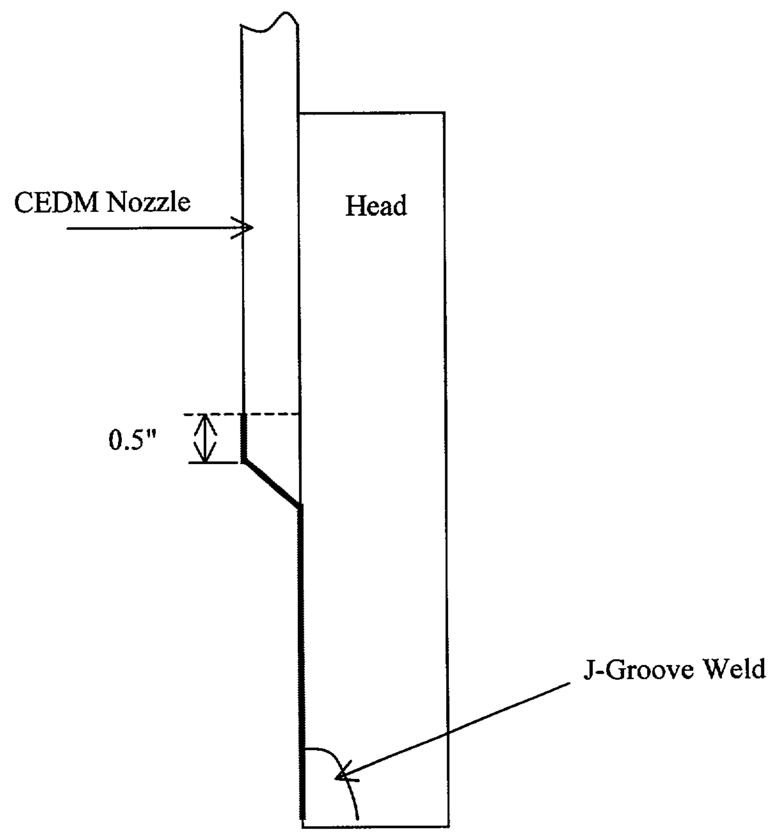


Figure 5
CEDM Temper Bead Weld Repair
PT Coverage Prior to Welding

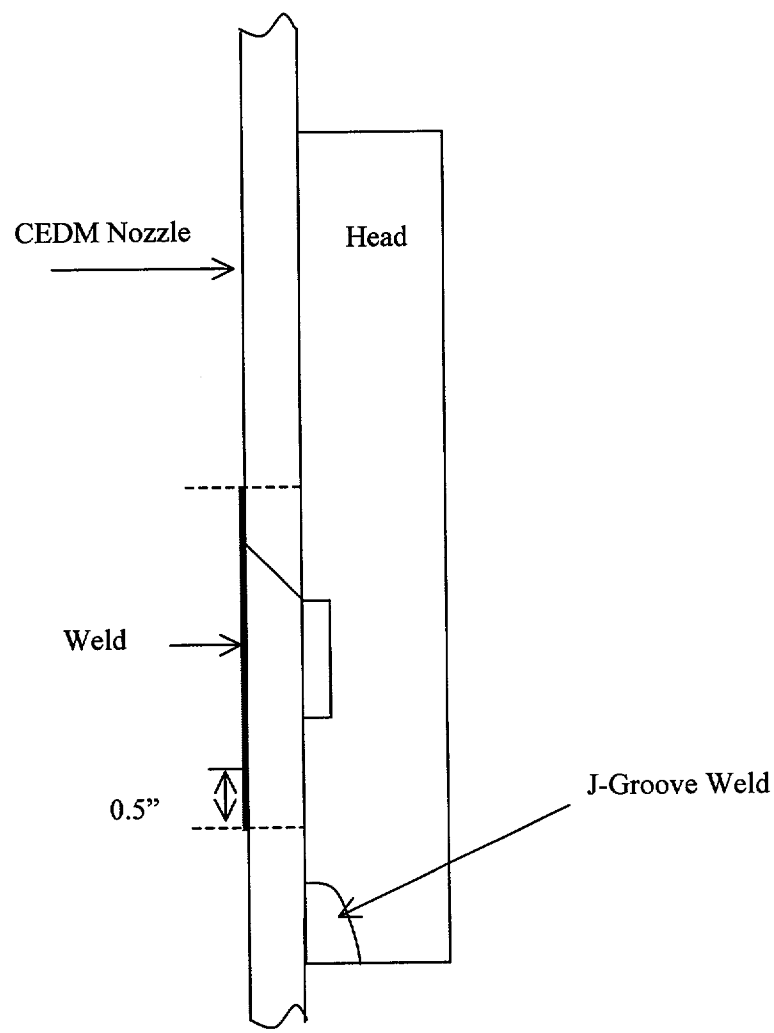


Figure 6
CEDM Temper Bead Weld Repair
PT Coverage After Welding

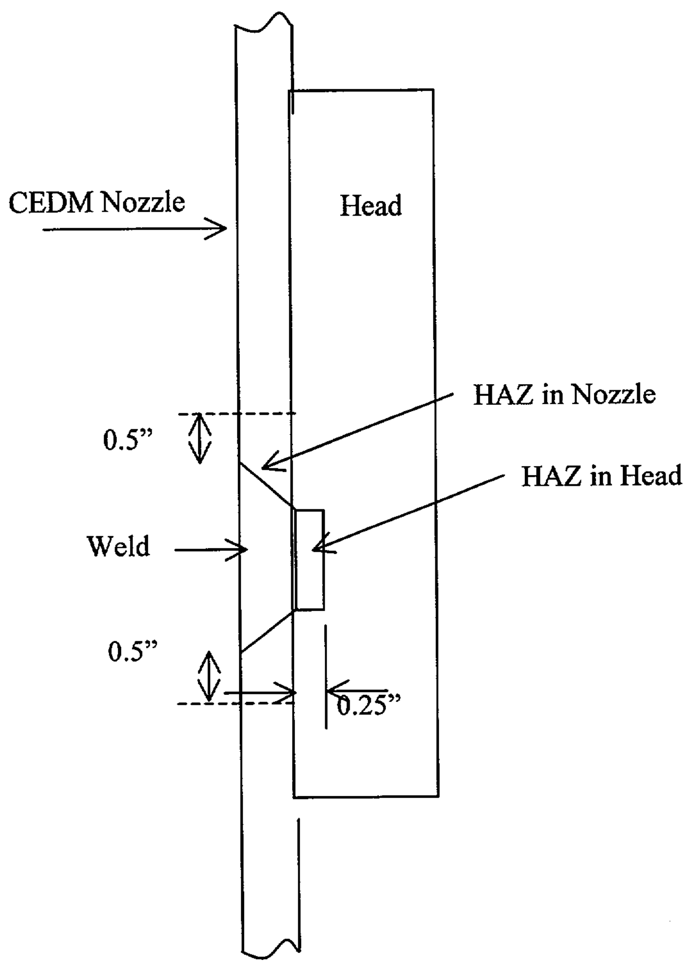


Figure 7
CEDM Temper Bead Weld Repair
Areas to be Examined

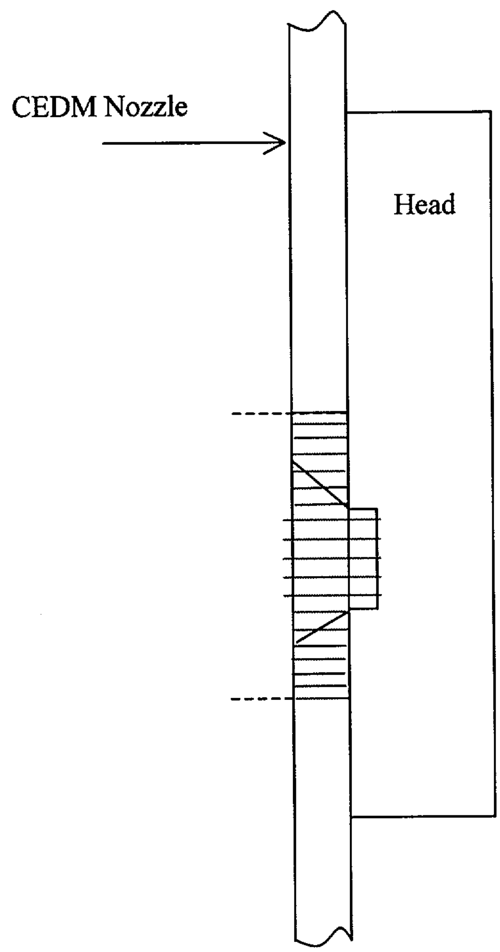


Figure 8
CEDM Temper Bead Weld Repair,
UT 0 degree and 45L Beam Coverage
Looking Clockwise and Counter-Clockwise

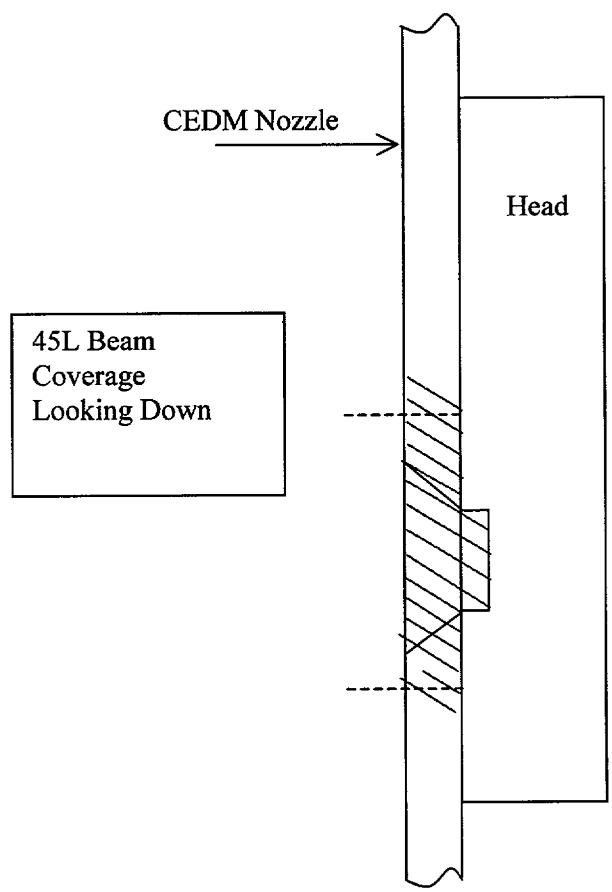


Figure 9
CEDM Temper Bead Weld Repair
45L UT Beam Coverage Looking Down

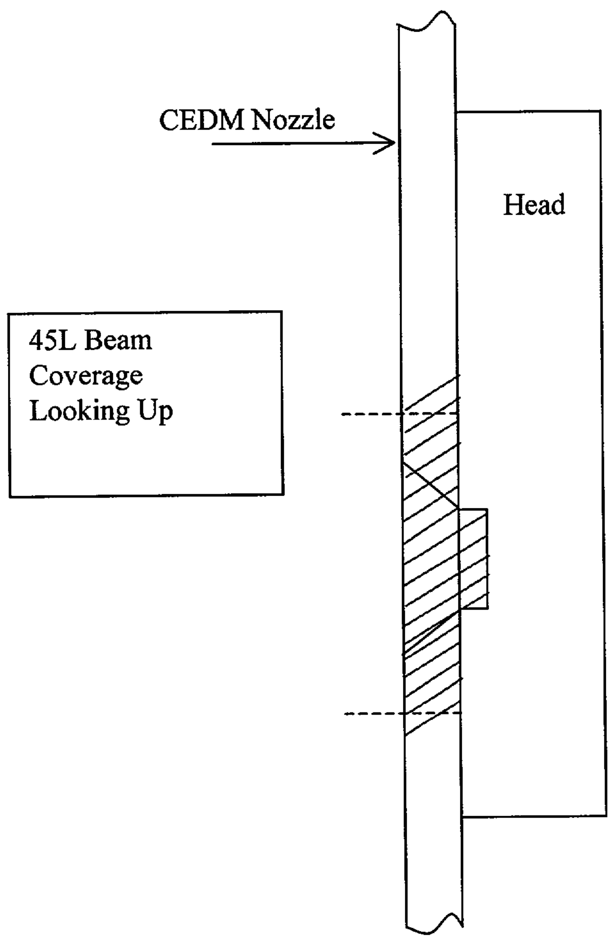


Figure 10
CEDM Temper Bead Weld Repair,
45L UT Beam Coverage Looking Up

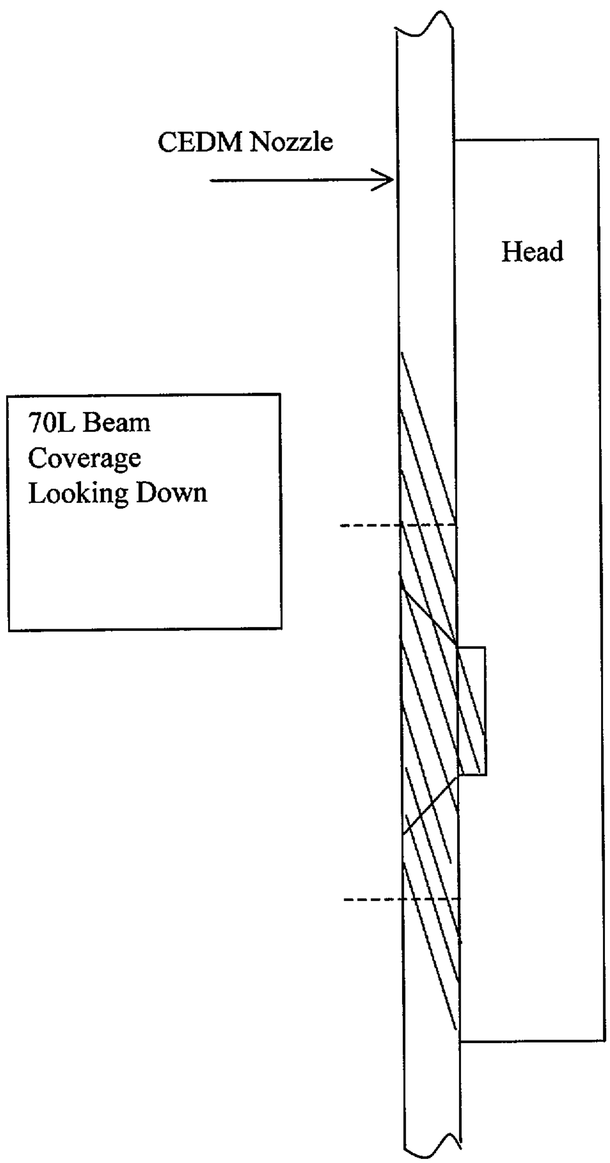


Figure 11
CEDM Temper Bead Weld Repair,
70L UT Beam Coverage Looking Down

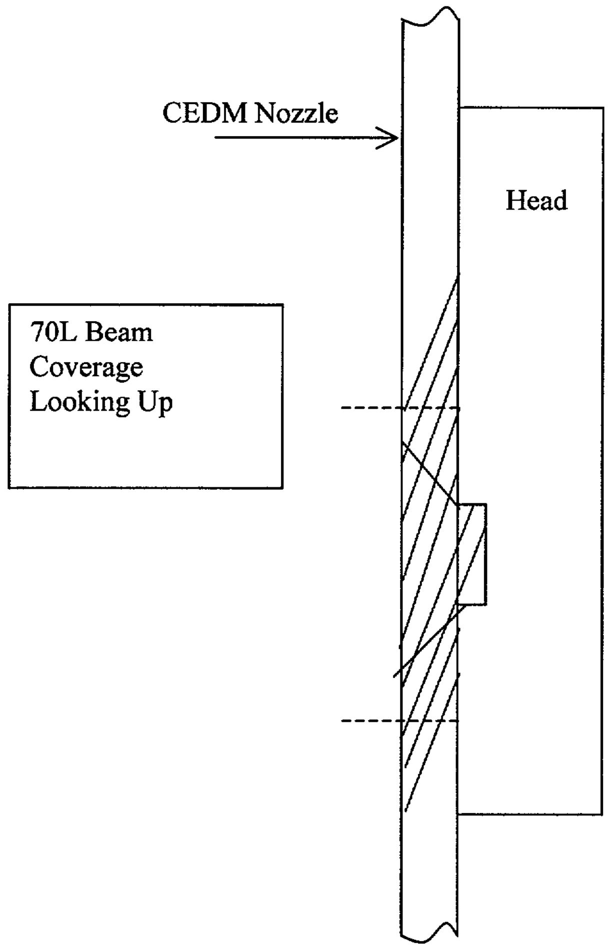


Figure 12
CEDM Temper Bead Weld Repair,
70L UT Beam Coverage Looking Up