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CNRO-2002-00031

June 17, 2002

U. S. Nuclear Regulatory Commission
Attn.: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Entergy Operations, Inc.
Response to NRC Request for Additional Information Regarding Proposed Alternative to ASME Examination Requirements for Repairs Performed on Reactor Vessel Head Penetrations (TAC No. MB4290)

Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6

REFERENCE:

1. Entergy Operations, Inc. Letter Nos. CNRO-2002-00007 and CNRO-2002-00021 to the NRC, "Proposed Alternative to ASME Examination Requirements for Repairs Performed on Reactor Vessel Head Penetrations," dated March 4, 2002, and April 4, 2002, respectively

2. NRC Letter to Entergy Operations, Inc., "Arkansas Nuclear One, Unit 2 – Request for Additional Information Regarding Proposed Alternative to American Society of Mechanical Engineers Boiler and Pressure Vessel Code Examination Requirements for Repairs Performed on Reactor Vessel Head Penetrations (TAC No. MB4290)," dated April 25, 2002

3. Entergy Operations, Inc. Letter No. 0CAN060202, "Submittal of Demonstration Report for Volumetric Examination of Vessel Head Penetration Nozzles," dated June 17, 2002

4. Entergy Operations, Inc. Letter No. CNRO-2002-00020 to the NRC, "Proposed Alternative to ASME Examination Requirements for Repairs Performed on Reactor Vessel Head Penetrations," dated April 2, 2002

Dear Sir or Madam:

In correspondence noted in Reference #1, Entergy Operations, Inc., (Entergy) recently submitted ASME Relief Request ANO2-R&R-001, Rev. 0 for Arkansas Nuclear One, Unit 2 (ANO-2). By ANO2-R&R-001, Entergy requested relief from performing examinations of base material weld repairs made to reactor pressure vessel (RPV) nozzles as required by ASME Section XI IWA-4331(a) and Section III NB-2539.4.

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During the course of review, the NRC staff determined that additional information was necessary to complete their review. The NRC staff transmitted via Reference #2 a Request for Additional Information (RAI) to support the review and approval of ANO2-R&R-001. Entergy's responses to the RAI are contained in Attachment 1.

In addition to the information provided in this letter, Entergy provided to the NRC staff via Reference #3 WesDyne Report #TJ-007-02, *Demonstration of Volumetric Ultrasonic Inspection of CRDM Nozzles Using the Open Housing Scanner for ANO-2*. This report details non-destructive examination (NDE) demonstrations performed by Westinghouse to confirm its capabilities to detect primary water stress corrosion cracking (PWSCC) in RPV head penetration nozzles and to examine repair welds. Rather than provide redundant information, Entergy references this report in various responses to RAI items, where applicable.

As a result of the responses to the RAI, Entergy has revised ANO2-R&R-001, Rev. 0. This revised request is contained in Attachment 2 and supercedes the previous request submitted to the NRC staff via Reference #1.

The information contained in Attachment 1 is also applicable to a similar request Entergy submitted for Waterford Steam Electric Station, Unit 3 (W3-R&R-001, Rev. 0) via Reference #4. Entergy plans to submit a revised request W3-R&R-001, Rev. 0, to reflect this information.

Should you have any questions regarding this letter, please contact Guy Davant at (601) 368-5756.

This letter contains no commitments.

Very truly yours,

M. A. Krupa

MAK/GHD/baa

Attachments:
1. Response to NRC Request for Additional Information Pertaining to Request No. ANO2-R&R-001, Rev. 0 (TAC No. MB4290) date April 25, 2002
2. Request ANO2-R&R-001, Rev. 0

cc: Mr. C. G. Anderson (ANO)
Mr. W. R. Campbell (ECH)
Mr. G. A. Williams (ECH)

Mr. T. W. Alexion, NRR Project Manager (ANO-2)
Mr. R. L. Bywater, NRC Senior Resident Inspector (ANO)
Mr. N. Kalyanam, NRR Project Manager
Mr. E. W. Merschoff, NRC Region IV Regional Administrator

ATTACHMENT 1

CNRO-2002-00031

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO REQUEST No. ANO2-R&R-001, Rev. 0 (TAC No. MB4290) DATED APRIL 25, 2002

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO REQUEST No. ANO2-R&R-001, Rev. 0 (TAC No. MB4290) DATED APRIL 25, 2002

1. Page10 [of ANO2-R&R-0001, Rev. 0] discusses the potential problems associated with welding over trapped liquid penetrant medium.

   a. According to EPRI [Electric Power Research Institute] Report GC-111050, any moisture on the surface of the component being welded will vaporize ahead of the welding process. The staff is unaware of studies performed on welding over entrapped liquid penetrant medium or of difficulties with chemical mixing of liquid penetrant constituents with Inconel weld material. Provide technical information on the effects of welding over liquid penetrant medium that is located in Section XI Code acceptable cracks.

   b. PT not only provides information on the original crack, it also verifies the crack characterization and monitors for cracks resulting from the metal removal process. In the absence of a PT examination, discuss efforts for verifying crack characterization and monitoring crack generation from the metal removal process.

Response to Item 1

Entergy has revised ANO2-R&R-001 to propose an alternative to performing a liquid penetrant examination of the repair cavity. Specifically, the discussion pertaining to potential problems associated with welding over a trapped liquid penetrant medium has been deleted. The revised ANO2-R&R-001 is provided in Attachment 2.

2. Page 10 [of ANO2-R&R-001] states that "the repair weld region will be re-examined using the ultrasonic and eddy current examination methods to verify the as left flaw dimensions are still within the acceptance limits of IWB-3600." Discuss the demonstrations that were used to establish the reliability and effectiveness of UT to detect and size cracks of different sizes prior to repair and after repair. Specifically, the orientation, kinds, types, number, ligaments, and characteristics of the flaws and the flaw locations in the mockup. Be specific about the value each mockup provided to the overall UT demonstration process. For instance, mockups used for calibration and instrumentation, for detecting circumferential inside surface PWSCC, or for sizing simulated PWSCC cracks beneath the weld.

Response to Item 2

Entergy provided to the NRC staff WesDyne Report #TJ-007-02, ***Demonstration of Volumetric Ultrasonic Inspection of CRDM Nozzles Using the Open Housing Scanner for ANO-2****, detailing the NDE demonstrations performed by Westinghouse to confirm its capabilities to detect PWSCC in RPV head penetration nozzles and to examine repair welds.*[1] *Please refer to the WesDyne report for descriptions of these demonstrations.*

a. Discuss the cold isostatic pressure - electric discharge machined (CIP EDM) notches used in the mockups. How was the acoustic characteristic determined and how does it compare to PWSCC? What is the average tip radius and tip radius standard deviation for the CIP EDM process?

Response to Item 2a

CIP is a low temperature, high-pressure process. Because deformation is produced at low temperature where the yield strength is high, much higher pressures relative to Hot Isostatic Processing (HIP) must be used to obtain adequate compression. In qualifying a flaw fabrication method for demonstration mockups, EPRI applied this technique to a section of a CRDM nozzle containing various EDM notch configurations. After squeezing the notches with CIP, EPRI then sectioned several of the notches and checked for changes in flaw width, depth, and length. EPRI test results indicated that EDM notches that were originally 0.015-inch wide were reduced to 0.002-inch. These tests also indicated that no substantial changes had occurred in flaw length and flaw depth during CIP. Page 5-4 of EPRI Report TR-106260 states in part, "As a result, CIP provides an excellent flaw compression technique that produces realistic flaw responses for eddy current and ultrasonic inspection methods. This technique also provides the ability to produce any flaw configuration while accurately controlling flaw dimensions such as length, depth, and shape. Figure 5-4 shows the tip of the notch and illustrates the crack-like sharpness and realistic irregularity of the resulting notch-tip." Although not addressed in the EPRI Report, EPRI reported to Entergy that the width of the crack tip is approximately 0.002-inch.

EPRI also compared NDE flaw responses of CIP flaws to real PWSCC flaws. To perform this comparison, EdF gave the EPRI NDE Center four cracked (PWSCC) penetration samples from the Bugey plant. Several parameters were evaluated during the comparison at Bugey. The most important of these parameters were:

- *Amplitude of the ultrasonic tip response*
- *Amplitude of the ultrasonic tip response relative to the surrounding noise level*
- *Phase of the ultrasonic tip response*

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[1] *Letter #0CAN060202 from Entergy to the NRC, "Submittal of Demonstration Report for Volumetric Examination of Vessel Head Penetration Nozzles," dated June 17, 2002*

- *Echo-dynamic features*

The results of the EPRI comparison or evaluation are addressed on Page 5-27 of EPRI Report TR-106260 and are summarized below.

- *"The amplitude of the ultrasonic tip responses varied only slightly. Differences when averaged over the length of a flaw did not vary more than +/-2dB. This was determined to be primarily due to minor variations in surface condition and ultrasonic coupling."*

- *"As shown in Figure 5-29, the signal-to-noise ratios were also very similar. The average signal-to-noise ratio observed was 3 to 1. The similarity in the phase angles of the simulated and field-removed cracks can also be seen in Figure 5-29."*

- *"There was no negligible difference observed between the echo-dynamic characteristics of the simulated and field-removed cracks. In most cases, notches create a slightly longer target motion than an actual crack due to the added width of the notch. Sound reflecting off the top of the notch contributes to both the length of the target motion and the amplitude of the overall response. However, as shown in Figure 5-4, the tip of the simulated crack is reduced by the CIP process and, as a result, there is no discernable change in amplitude or target motion."*

In conclusion, the ultrasonic data evaluations performed at Bugey proved that examination responses on CIP flaws closely matched the responses from the Bugey PWSCC samples. The Abstract of EPRI Report TR-106260 states:

> *"Mockup and flaw fabrication methods were qualified by comparing the ultrasonic and eddy current responses of the mockup flaws with real primary water stress corrosion cracking (PWSCC) in penetration samples from Electricite de France's (EdF's) Bugey plant. The comparisons showed that the mockup flaws simulated real PWSCC closely in all essential features important to inspection demonstration."*

Page 5-4 of the EPRI Report TR-106260 also documents the following observation:

> *"The resulting flaws exhibited representative flaw responses during both eddy current and ultrasonic flaw signal evaluations, without any of the anomalies encountered in the HIP-produced flaws. The capability to produce realistic flaw responses for both inspection techniques avoided the need to produce separate flaw samples for eddy current and ultrasonic demonstrations."*

b. Discuss the representativeness of the mockup flaws to PWSCC originating from inside and outside surfaces of the CRDM.

Response to Item 2b

Westinghouse performed several demonstrations to confirm their capability to detect and size inner diameter (ID)-initiated and outer diameter (OD)-initiated flaws in RPV head penetration nozzles. These demonstrations with a discussion of the flaw mockups are discussed in WesDyne Report #TJ-007-02. Please refer to this report for the requested information.

c. Discuss the effects of different inside diameter weld thickness on the ability of UT examinations to detect and size the flaws below the repair weld. Discuss the capabilities of the UT to size cracks extending from the J-groove/CRDM interface and below the repair weld.

Response to Item 2c

Upon completing repair welding of an RPV head penetration nozzle, the crown of the repair weld will be machined flush with the surrounding base material using the EDM process. Therefore, the final repair weld configuration will be the same contour as the ID of the respective RPV head penetration nozzle. (Entergy has submitted a request to use the EDM process[2] and has obtained verbal approval of this request from the NRC.)

Westinghouse demonstrations, as described in WesDyne Report #TJ-007-02, provide assurance that the ultrasonic examination procedure is capable of satisfactorily examining repair welds in RPV head penetration nozzles. These demonstrations also provide assurance that if an as-left flaw under a repair weld grows axially above or below the repair weld during the repair process, then the Westinghouse examination procedure would identify the flaw growth. In addition, the demonstration on the welded repair mockup confirmed the capability of Westinghouse's procedure to detect weld flaws in the repair weld and flaws in the tube below the repair weld.

d. Provide the technical justification, signal-to-noise ratios showing the presence of different type/size flaws, layout of flaw locations in the mockups, calibrations, and UT procedure. Discuss the effectiveness detecting and measuring ligaments. The justification should contain sufficient detailed information for a third party UT expert to arrive at the same detection and characterization conclusions, i.e. digital images of qualification test data depicting flaw detection.

Response to Item 2d

As stated in the Response to Item 2a, above, WesDyne Report #TJ-007-02 details the NDE demonstrations performed by Westinghouse to confirm its capabilities to

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[2] *Letter #CNRO-2002-00013 from Entergy to the NRC, "Use of Electric Discharge Machining (EDM)," dated March 14, 2002*

detect PWSCC in RPV head penetration nozzles and to examine repair welds. Please refer to the WesDyne report for the requested information.

Regarding signal-to-noise ratios, flaws in the EPRI Generic Letter 97-01 mock-up and the Entergy/EPRI Materials Reliability Project (MRP) mock-up demonstrations were fabricated using the EDM and CIP processes. Signal-to-noise ratios for these flaws are addressed in Entergy's Response to item 2a. Because the MRP Bulletin 2001-01 demonstration was performed on Oconee samples with actual PWSCC, the signal-to-noise ratios were based upon actual PWSCC.

ATTACHMENT 2

CNRO-2002-00031

REQUEST ANO2-R&R-001, Rev. 0

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNIT 2
3RD 10-YEAR INTERVAL
REQUEST NO. ANO2-R&R-001, REV. 0

I. COMPONENT/EXAMINATION

Component/Number: 2R-1

Description: Reactor Pressure Vessel (RPV) Head Penetration Nozzles

Code Class: 1

References:

1. ASME Section XI, 1992 Edition with portions of the 1993 Addenda as listed in Reference 5
2. ASME Section III, Subsection NB, 1968 Edition, Summer 1970 Addenda
3. ASME Section III, Subsection NB, 1989 Edition
4. ASME Section III, Subsection NB, 1992 Edition, 1993 Addenda
5. CEP-ISI-004, "Arkansas Nuclear One Unit 2 Inservice Inspection Plan"
6. Letter 2CAN090102, "30 Day Response to NRC Bulletin 2001-01 for ANO-2; Circumferential Cracking of VHP Nozzles," dated September 4, 2001
7. Letter CNRO-2002-00013 from Entergy Operations, Inc. to the NRC, "Use of Electrical Discharge Machining," dated March 14, 2002
8. Letter 0CAN060202 from Entergy Operations, Inc. to the NRC, "Submittal of Demonstration Report for Volumetric Examination of Vessel Head Penetration Nozzles," dated June 17, 2002

Unit: Arkansas Nuclear One, Unit 2 (ANO-2)

Inspection Interval: Third (3rd) 10-Year Interval

II. REQUIREMENTS

Subarticle IWA-4170(b) of ASME Section XI, 1992 Edition states: "Repairs and installation of replacement items shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used."

The original construction code for the ANO-2 RPV is ASME Section III, Subsection NB, 1968 Edition, Summer 1970 Addenda (Reference 2). As allowed by ASME Section XI, localized weld repairs of the RPV head penetration nozzle base materials will be performed in accordance with the 1989 Edition of ASME Section III. The applicable ASME Section III requirements are discussed below.

- NB-4000

  NB-4000 establishes fabrication, installation, and repair requirements for ASME Class 1 components. According to NB-4131, when defects are identified in materials that exceed the limits of NB-2500, then the condition is corrected in accordance with the requirements of NB-2500 for the applicable product form, with the exception that the limitation on depth of weld repair does not apply. As shown in Section III of this relief request, the ANO-2 RPV head penetration nozzles are manufactured from SB-166 round bar and SB-167 pipe/tube. Based on the ASME Code, the repair requirements of NB-2550 apply to all of the RPV head penetration nozzles.

- NB-2559

  NB-2550 establishes examination and repair requirements that are applicable to ASME Class 1 tubular products such as RPV head penetration nozzles. NB-2559 establishes requirements for performing localized repairs by welding. NB-2559 states, "Repair of defects shall be in accordance with NB-2539, except repair by welding is not permitted on copper-nickel alloy or nickel alloy materials." Based on this requirement, localized repair welding of the RPV head penetration nozzle base materials is performed in accordance with NB-2539.

  NB-2559 also includes a restriction that prohibits repair welding on copper-nickel alloy or nickel alloy materials. Although not specifically stated, this restriction was only intended to apply to heat exchanger tubing; it was not intended to restrict welding repairs of other copper-nickel or nickel alloy materials such as nozzles. The ASME Code corrected this requirement in the 1993 Addenda of the 1992 Edition as follows: "Repair of defects shall be in accordance with NB-2539, except repair by welding is not permitted on copper-nickel alloy or nickel alloy heat exchanger tubes." Therefore, repair welding of RPV head penetration nozzles base material can be performed in accordance with NB-2539 as clarified by the 1993 Addenda of ASME Section III.

- NB-2539

  NB-2539 establishes requirements for performing repairs by welding. These requirements address defect removal, qualification of welding procedures and welders, blending of repaired areas, and examination of repair welds. As invoked by NB-2559, these requirements apply to localized weld repairs of RPV head penetration nozzles. Examination requirements for completed repair welds are specified in NB-2539.4 as follows: "Each repair weld shall be examined by the magnetic particle or liquid penetrant method. In addition, when the depth of the repair cavity exceeds the lesser of 3/8-inch or 10% of the section thickness, the repair weld shall be radiographed after repair in accordance with NB-5110 and to the acceptance standards of NB-5320."

ASME Section XI also imposes repair requirements that supplement or amend the repair rules of the construction code. Where applicable, compliance with these additional requirements is mandatory. With respect to localized repair welding of RPV head penetration nozzle base materials, the following supplemental requirements apply:

- IWA-4310

  IWA-4310 establishes requirements for performing defect removal. These requirements also permit the acceptance of unremoved portions of flaws based upon the flaw evaluation rules of ASME Section XI. Supplementing the defect removal requirements in ASME Section III, the requirements of IWA-4310 apply to the performance of localized weld repairs of RPV head penetration nozzle base materials.

  IWA-4310 states: "Defects shall be removed or reduced in size in accordance with this paragraph. The component shall be acceptable for continued service if the resultant section thickness created by the cavity is equal to or greater than the minimum design thickness. If the resulting section thickness is reduced below the minimum design thickness, the component shall be repaired or replaced in accordance with this Article. Alternatively, the defect removal area and any remaining portion of the flaw may be evaluated and the component accepted in accordance with appropriate flaw evaluation rules of Section XI or the design rules of either the construction code, or Section III, when the Construction Code was not Section III."

- IWA-4331(a)

  IWA-4331(a) establishes nondestructive examination requirements that are applicable to defect removal surfaces including surfaces of repair cavities prepared for welding. Supplementing the examination requirements in ASME Section III, IWA-4331(a) applies to localized weld repairs in RPV head penetration nozzle base materials.

IWA-4331(a) states: "After final grinding, the affected surfaces, including surfaces of cavities prepared for welding, shall be examined by the magnetic particle or liquid penetrant method to ensure that the indication is reduced to an acceptable limit in accordance with IWA-3000. This examination is not required when defect elimination removes the full thickness of the weld and the back side of the weld joint is not accessible for removal of examination materials."

III. PROPOSED ALTERNATIVES

A. Background

The ANO-2 RPV head has 90 penetrations that include 81 control element drive mechanism (CEDM) nozzles, 8 incore instrument (ICI) nozzles, and 1 vent line nozzle. Details of the nozzles are provided in Figures 1 and 2. The materials and dimensions of the RPV head penetration nozzles are summarized below.

RPV Penetration Nozzle	Material	Dimensions		
		Outside Dia.	Inside Dia.	Thickness
CEDM	SB-166, N06600	4.050"	2.718"	0.6660"
ICI	SB-167, N06600	5.563"	4.750"	0.4065"
Vent Line	SB-167, N06600	1.050"	0.742"	0.1540"

These nozzles are considered to have a moderate susceptibility to Primary Water Stress Corrosion Cracking (PWSCC) based upon a susceptibility ranking of greater than 5 effective full power years (EFPY) but less than 30 EFPY from the Oconee Nuclear Station – Unit 3 time-at-temperature condition. The ANO-2 susceptibility ranking was reported to the NRC in ANO-2's response to NRC Bulletin 2001-01 (Reference 6).

Examinations of RPV head penetration nozzles will be performed as described in ANO-2's response to NRC Bulletin 2001-01 (Reference 6). Based on inspection results, the following repairs may be required:

- Localized weld repairs of RPV head penetration nozzle base materials along the inside diameter of the nozzle, above the J-weld. See Figures 2 and 3.
- Localized weld repairs of RPV head penetration nozzle base materials along the inside diameter of the nozzle, adjacent to the J-weld. See Figures 2 and 4.
- Localized weld repairs of RPV head penetration nozzle base materials along the inside diameter of the nozzle, below the J-weld. See Figures 2 and 5.
- Localized weld repairs of RPV head penetration nozzle base materials along the outside diameter of the nozzle below the J-weld. See Figures 2 and 6.

This request addresses nondestructive examination (NDE) associated with the above repairs. However, it does not apply when a temper bead welding process is utilized to perform weld repairs of RPV head penetration nozzle base materials. Additionally, this relief request does not apply to weld repairs of RPV head penetration nozzle J-welds.

An overview of ASME Code requirements applicable to the above base material repair scenarios is provided below. This overview identifies the various examination sequences required by the Construction Code and ASME Section XI.

Localized Weld Repair of RPV Head Penetration Nozzle Base Materials

1. **Defect Removal**: Defects are either removed or reduced in size in accordance with IWA-4310. The IWA-4310 defect removal requirements are consistent with NB-2539.1 in that both of these paragraphs require that the defect be removed or reduced to an imperfection of acceptable size. However, IWA-4310 also includes a provision that allows acceptance of a defect removal area and an unremoved portion of a flaw based on an evaluation performed "in accordance with the appropriate flaw evaluation rules of ASME Section XI". The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2539.1 states in part: "The defect shall be removed or reduced to an imperfection of acceptable size..."

   - ASME Section XI, IWA-4310 states: "Defects shall be removed or reduced in size in accordance with this paragraph. The component shall be acceptable for continued service if the resultant section thickness created by the cavity is equal to or greater than the minimum design thickness. If the resulting section thickness is reduced below the minimum design thickness, the component shall be repaired or replaced in accordance with this Article. Alternatively, the defect removal area and any remaining portion of the flaw may be evaluated and the component accepted in accordance with appropriate flaw evaluation rules of Section XI or the design rules of either the construction code, or Section III, when the Construction Code was not Section III."

2. **Defect Removal Methods**: When defects are removed using a thermal removal process, a minimum of 1/16-inch of material must be mechanically removed from the thermally processed areas in accordance with IWA-4322. The ASME Section XI requirement pertaining to defect removal supplements the defect removal requirements of ASME Section III. While both ASME Sections III and XI allow use of thermal and mechanical removal processes, only ASME Section XI requires the mechanical removal of 1/16-inch (minimum) of material from all thermally processed areas. The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2539.1 states in part: "The defect shall be removed or reduced to an imperfection of acceptable size by suitable mechanical or thermal cutting or gouging methods..."

- ASME Section XI, IWA-4322 states: "If thermal removal processes are used on P-No. 8 and P-No. 43 materials, a minimum of 1/16-inch material shall be mechanically removed from the thermally processed areas."

- ASME Section XI, IWA-4330 allows the use of mechanical removal processes on defect removal areas in repair weld cavities.

As an alternative to IWA-4322 (separate from this request), Entergy plans to use the electrical discharge machining (EDM) process to perform defect removal based on NRC approval of Relief Request PWR-R&R-002, Revision 0 (Reference 7).

3. **Preparation of Repair Cavity**: Repair cavities for localized weld repairs of RPV head penetration nozzle base materials are prepared in accordance with IWA-4330. The ASME Section XI requirements in IWA-4330 supplement the repair cavity preparation requirements of ASME Section III. Although NB-2539.1 of ASME Section III states that the repair cavity is to be prepared for welding, it does not establish requirements to accomplish this. IWA-4330(b) does. According to IWA-4330(b), the repair cavity must be ground smooth and clean with beveled sides and edges rounded to provide suitable accessibility for welding. The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2539.1 states in part: "The defect shall be removed or reduced to an imperfection of acceptable size ... and the cavity prepared for welding."

   - ASME Section XI, IWA-4330(b) states: "Where repair welding is required, the cavity shall be ground smooth and clean with beveled sides and edges rounded to provide suitable accessibility for welding."

4. **Repair Cavity Examination:** Prior to welding, the repair cavity is examined by the liquid penetrant method in accordance with IWA-4331(a). [Although IWA-4331(a) allows either a liquid penetration examination or a magnetic particle examination, a magnetic particle examination cannot be performed since the nozzle material to be examined is non-magnetic.] Although NB-2558(b) of ASME Section III specifies that the repair cavity is to be examined by the examination method that originally disclosed the defect, IWA-4331(a) of ASME Section XI amends this requirement by requiring a liquid penetrant examination regardless of product form. [Note that NB-2539, as invoked by NB-2559, does not address examination of the repair cavity. Repair cavity examinations are performed in accordance with NB-2558(b)]. The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2558(b) states: "After defect elimination, the area is examined by the method which originally disclosed the defect to assure that the defect has been removed or reduced to an imperfection of acceptable size."

- ASME Section XI, IWA-4331(a) states: "After final grinding, the affected surfaces, including surfaces of cavities prepared for welding, shall be examined by the magnetic particle or liquid penetrant method to ensure that the indication is reduced to an acceptable limit in accordance with IWA-3000. This examination is not required when defect elimination removes the full thickness of the weld and the back side of the weld joint is not accessible for removal of examination materials."

  Entergy proposes an alternative to the repair cavity examination requirements of IWA-4331(a) in Section III.B.1.a, below.

5. **Qualification of Welding Procedures and Welders:** Welding procedures and welders or welding operators are qualified in accordance with NB-4000 of ASME Section III and ASME Section IX as required by NB-2539.2. ASME Section XI invokes the qualification requirements of ASME Section III without specifying any supplements or amendments. The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2539.2 states: "The welding procedures and welders or welding operators shall be qualified in accordance with NB-4000 and Section IX."

   - ASME Section XI, IWA-4170(b) states: "Repairs and installation of replacement items shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used."

6. **Blending of Repaired Areas:** The weld surface is blended uniformly into the surrounding surface after completing the repair as required by NB-2539.3. ASME Section XI invokes the repair requirements of ASME Section III without specifying any supplements or amendments. The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2539.3 states: "After repair, the surface shall be blended uniformly into the surrounding surface."

   - ASME Section XI, IWA-4170(b) states: "Repairs and installation of replacement items shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used."

7. **Examination of Repair Welds:** Repair welds in RPV head penetration nozzles are examined by the liquid penetrant method in accordance with NB-2539.4. When the repair cavity depth exceeds the lesser of 3/8-inch or 10% of the section thickness, a radiographic examination of the repair weld is also required by NB-2539.4. ASME Section XI invokes the ASME Section III examination requirements without specifying any supplements or amendments. The applicable paragraphs of ASME Sections III and XI are provided below.

   - ASME Section III, NB-2539.4 states: "Each repair weld shall be examined by the magnetic particle or liquid penetrant method. In addition, when the depth of the repair cavity exceeds the lesser of 3/8-inch or 10% of the section thickness, the repair weld shall be radiographed after repair in accordance with NB-5110 and to the acceptance standards of NB-5320."

   - ASME Section XI, IWA-4170(b) states: "Repairs and installation of replacement items shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used."

   Entergy proposes alternatives to the examination requirements of NB-2539.4 in Sections III.B.1.b and III.B.2, below.

B. <u>Proposed Alternatives</u>

1. 10CFR50.55a(a)(3)(i) Alternatives:

   Pursuant to the provisions of 10CFR50.55a(a)(3)(i), Entergy proposes alternatives to examination requirements applicable to localized repair welds in RPV head penetration nozzle base materials specified in ASME Section XI IWA-4331(a) and ASME Section III NB-2539.4. Specifically, Entergy proposes the following alternatives:

   a. As an alternative to a magnetic particle or liquid penetrant examination of the repair cavity in accordance with IWA-4331(a) of ASME Section XI, Entergy proposes to perform the following:

      1) **Flaw Characterization:** Prior to defect removal, RPV head penetration nozzles will be examined by the ultrasonic and eddy current examination methods to characterize all flaws.

      2) **Flaw Evaluation**: All flaws in RPV head penetration nozzles will be evaluated for acceptance. Flaws that exceed the acceptance limits of the flaw evaluation will be reduced to an acceptable size prior to welding.

3) **Examination of Repair Weld**: Upon completion of welding, the repair weld will be examined by the ultrasonic and eddy current methods to verify that the as-left dimensions of the flaw comply with the acceptance limits. When the eddy current examination cannot be performed due to the surface profile of the repair weld or other prohibitive conditions, then a liquid penetrant examination will be performed as an alternative.

- Ultrasonic examinations will be performed as described in Section IV.A. Acceptance criteria shall be in accordance with NB-5330.
- Eddy current examinations will be performed as described in Section IV.A.
- The liquid penetrant examination and acceptance criteria will be in accordance with NB-2546 of ASME Section III.

b. As an alternative to a magnetic particle or liquid penetrant examination of the completed repair weld in accordance with NB-2539.4 of ASME Section III, Entergy proposes to perform an eddy current examination. When an eddy current examination cannot be performed due to the surface profile of the repair weld or other prohibitive conditions, then a liquid penetrant examination will be performed.

- Eddy current examinations will be performed as described in Section IV.B.
- The liquid penetrant examination and acceptance criteria will be in accordance with NB-2546 of ASME Section III.

2. 10CFR50.55a(g)(5)(iii) Alternative:

Pursuant to the provisions of 10CFR50.55a(g)(5)(iii), Entergy requests relief from ASME Section III NB-2539.4, which requires a radiographic examination of completed repair welds when the depth of the repair cavity exceeds the lesser of 3/8-inch or 10% of the section thickness. As an alternative to this examination, Entergy proposes to perform ultrasonic and eddy current examinations, as follows:

- Ultrasonic examinations will be performed as described in Section IV.C. Acceptance criteria shall be in accordance with NB-5330.
- Eddy current examinations will be performed as described in Section IV.C.

The alternatives proposed in Sections III.B.1.a, III.B.1.b, and III.B.2, above, are specific to the repairs described below.

- Localized weld repairs of RPV head penetration nozzle base materials along the inside diameter of the nozzle, above the J-weld. See Figures 2 and 3.
- Localized weld repairs of RPV head penetration nozzle base materials along the inside diameter of the nozzle, adjacent to the J-weld. See Figures 2 and 4.

- Localized weld repairs of RPV head penetration nozzle base materials along the inside diameter of the nozzle, below the J-weld. See Figures 2 and 5.

- Localized weld repairs of RPV head penetration nozzle base materials along the outside diameter of the nozzle below the J-weld. See Figures 2 and 6.

IV. BASIS FOR PROPOSED ALTERNATIVES

A. IWA-4331(a) – Surface Examination of Repair Cavity (see Section III.B.1.a)

IWA-4331(a) of ASME Section XI requires a magnetic particle or liquid penetrant examination of all repair cavities prior to repair welding. Magnetic particle testing is a nondestructive examination method used to detect surface and near-surface discontinuities in magnetic materials. The basic principle of magnetic particle inspection is that when a ferromagnetic material contains one or more discontinuities in the path of the magnetic flux, minute poles are set up at the discontinuities. These poles have a stronger attraction for the magnetic particles than the surrounding surface of the material. However, the ANO-2 RPV head penetration nozzles are manufactured from SB-166 and SB-167 nickel alloys, which are not magnetic. Therefore, examination of repair weld cavities in RPV head penetration nozzles by the magnetic particle method is not possible.

Liquid penetrant testing is a nondestructive method that reveals open-surface discontinuities by bleed-out of a liquid penetrant medium against a contrasting background developer. The technique is based on the ability of a penetrating liquid to wet the surface opening or crevice of a discontinuity and to be drawn into the discontinuity by capillary action. If the discontinuity is significant, penetrant will be held in the cavity when the excess is removed from the surface. Upon application of a developer, blotter action draws the penetrant from the discontinuity to provide a contrasting indication on the surface. When a surface examination of an RPV head penetration nozzle is required, liquid penetrant would be the appropriate examination method.

Suitability of Proposed Alternative

RPV head penetration nozzles will be examined by the ultrasonic and eddy current examination methods as described below to characterize all flaws prior to defect excavation. Identified flaws will be evaluated for acceptance in accordance with IWB-3600. Flaws that exceed the acceptance limits of the IWB-3600 flaw evaluation will be removed or reduced to an acceptable size prior to welding. Upon completion of repair welding, the repair weld region will be re-examined using the ultrasonic and eddy current examination methods to verify that the as-left flaw dimensions are still within the acceptance limits of the IWB-3600 flaw evaluation. In the unlikely event that an eddy current examination cannot be performed due to the surface profile of a repair weld or some other prohibitive condition, then a liquid penetrant examination will be performed as an alternative. In conclusion, a surface examination is performed on a repair cavity to ensure that cracks and other unacceptable defects have been removed prior to welding. However, when a flaw is left in the component by design in accordance with IWA-4310, then a surface examination of the repair cavity is no longer beneficial. Conversely, the proposed

alternative ensures that the structural integrity of the RPV head penetration nozzle is maintained.

The ultrasonic examination will be performed using a combination of Time of Flight Diffraction (TOFD) and standard 0° pulse-echo techniques. The TOFD approach utilizes two pairs of 0.250-inch diameter, 55° refracted-longitudinal wave transducers pointed at each other. One of the transducers sends sound into the inspection volume, and the other transducer receives the reflected and diffracted signals, as they interact with the material. There will be one TOFD pair looking in the axial direction of the penetration tube, and one TOFD pair will be looking in the circumferential direction of the penetration tube. The TOFD technique is primarily responsible for detecting and characterizing planer-type defects within the full volume of the penetration tube. This TOFD ultrasonic technique will be used in the pre-inspections for flaw characterization and in the post-repair inspections.

The standard 0° pulse-echo ultrasonic approach utilizes two 0.250-inch diameter straight beam transducers. One transducer uses a center frequency of 2.25 MHz while the other uses a frequency of 5.0 MHz. The 0° technique is primarily responsible for plotting the penetration tube outside diameter location and the J-groove attachment weld location, which will aid in defect orientation and sizing information. Additionally, the 0° technique will be capable of locating and sizing any laminar-type defects that may be encountered. These transducers will interrogate the weld repair area for lack of fusion and other laminar-type defects. This ultrasonic technique will be used in the pre-inspections for flaw characterization and in the post-repair inspections.

The eddy current examination complements the ultrasonic examination by providing sensitivity to surface and subsurface flaws along the inspection surface. The eddy current approach utilizes a 5-mm diameter, "cross wound" probe design, which is capable of operating frequencies between 75 and 500 kHz. This technique is primarily responsible for detection and length sizing of defects, which are open to the inside diameter surface of the penetration tube. Since this particular probe design produces eddy currents that penetrate to approximately 0.030-inch into the inside diameter surface, it will also aid in the evaluation of very shallow surface defects. For post-repair inspection purposes, this eddy current examination technique will provide the necessary surface examination of the weld repair area. This eddy current technique will be used in the pre-inspections for flaw characterization and in the post-repair inspections.

The above ultrasonic and eddy current examination techniques have been demonstrated capable of detecting axial and circumferential PWSCC indications in the nozzle material, utilizing cracked nozzle samples. Entergy submitted a detailed summary of these demonstrations to the NRC staff via Reference 8. Please refer to that report for descriptions of these demonstrations.

B. <u>NB-2539.4 – Surface Examination of Repair Welds</u> (see Section III.B.1.b)

NB-2539.4 of ASME Section III requires a magnetic particle or liquid penetrant examination of all repair welds. However, a magnetic particle examination of repair welds in RPV head penetration nozzles cannot be performed. Magnetic particle testing is a nondestructive method used to detect surface and near-surface

discontinuities in magnetic materials. The basic principle of magnetic particle inspection is that when a ferromagnetic material contains one or more discontinuities in the path of the magnetic flux, minute poles are set up at the discontinuities. These poles have a stronger attraction for the magnetic particles than the surrounding surface of the material. However, the ANO-2 RPV head penetration nozzles are manufactured from SB-166 and SB-167 nickel alloys, which are not magnetic. Repair welds will be performed using inconel filler metals that are also non-magnetic. Therefore, examination of repair welds in RPV head penetration nozzles by the magnetic particle method is not possible.

Suitability of Proposed Alternative

Eddy current examinations have been proposed as an alternative to magnetic particle testing. The eddy current examination provides sensitivity to surface and subsurface flaws along the inspection surface. More details on the eddy current examination method are provided in Section IV.A, above.

A liquid penetrant examination of repair welds in RPV head penetration nozzle base materials is an acceptable examination according to NB-2539.4. Liquid penetrant testing is a nondestructive method that reveals open-surface discontinuities by bleed-out of a liquid penetrant medium against a contrasting background developer. The technique is based on the ability of a penetrating liquid to wet the surface opening or crevice of a discontinuity and to be drawn into the discontinuity by capillary action. If the discontinuity is significant, penetrant will be held in the cavity when the excess is removed from the surface. Upon application of a developer, blotter action draws the penetrant from the discontinuity to provide a contrasting indication on the surface. A liquid penetrant examination will only be performed when the eddy current examination cannot be performed due to the surface profile of a repair weld or some other prohibitive condition.

C. NB-2539.4 – Radiographic Examination of Repair Welds (see Section III.B.2)

NB-2539.4 requires a radiographic examination of base material repair welds when the depth of the repair cavity exceeds the lesser of 3/8-inch or 10% of the section thickness. However, a radiographic examination of the repair weld cannot be performed.

Impracticality of Radiographic Examinations

Radiographic examination of weldments employs x-rays or gamma rays to penetrate an object and detect discontinuities by the resulting image on a recording or a viewing medium such as photographic film. When a weld is exposed to radiation, some of the radiation is absorbed, some scattered, and some transmitted through the weldment to the film. The variations in amount of radiation transmitted through the weld depend on (1) relative densities of the material and any inclusions, (2) through-thickness variations, and (3) the characteristic of the radiation itself. Nonmetallic inclusions, pores, aligned cracks, and other discontinuities result in more or less radiation reaching the recording film. The variations in transmitted radiation produce optically contrasting areas on the recording film.

Radiography is not appropriate for base material weld repairs of RPV head penetration nozzles. Radiographic techniques require that the source of radiation be placed as near normal to the item being examined as possible, with the film in intimate contact with the item on the opposite surface. An attempt to radiograph repair welds in the RPV head penetration nozzles would have the radiation source being placed at various angles other than normal, penetrating from fractions of an inch of material thickness up to multiple inches of material thickness. Image quality indicators (penetrameters) would have to be placed on the inside bores of the RPV head penetration nozzles. Multiple exposures would be required, and the image distortion would increase as the repair weld moved up the nozzle bore. The required radiographic sensitivity and geometric unsharpness would also not be obtainable with generally used radiographic techniques. Depending on the location of the repair weld, access to both surfaces of the RPV nozzle may not be available to allow radiographic examinations. In other cases, clearances between the RPV nozzles and the RPV head would make radiography of a repair weld impossible. Multiple exposures, complex geometry and thickness, and the adverse radiological environment make radiographic examination of RPV head penetration nozzle repair welds impractical.

Suitability of Proposed Alternative

Meaningful radiographic examination of repair welds in RPV head penetration nozzle base materials cannot be performed. As an alternative, Entergy proposes to utilize the ultrasonic and eddy current examination methods. The ultrasonic examination method will use a combination of Time of Flight Diffraction (TOFD) and standard 0° pulse-echo techniques. These examination methods are discussed in more detail in Section IV.A, above.

V. CONCLUSION

A. 10CFR50.55a(a)(3) states:

"Proposed alternatives to the requirements of (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The applicant shall demonstrate that:

(i) The proposed alternatives would provide an acceptable level of quality and safety, or

(ii) Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

Entergy believes that the proposed alternatives identified Sections III.B.1.a and III.B.1.b, and discussed in Sections IV.A and IV.B, above, provide an acceptable level of quality and safety to the repair rules as stated in Reference 1 and as described in Section II of this request. Therefore, we request that the proposed alternative be authorized pursuant to 10CFR50.55a(a)(3)(i).

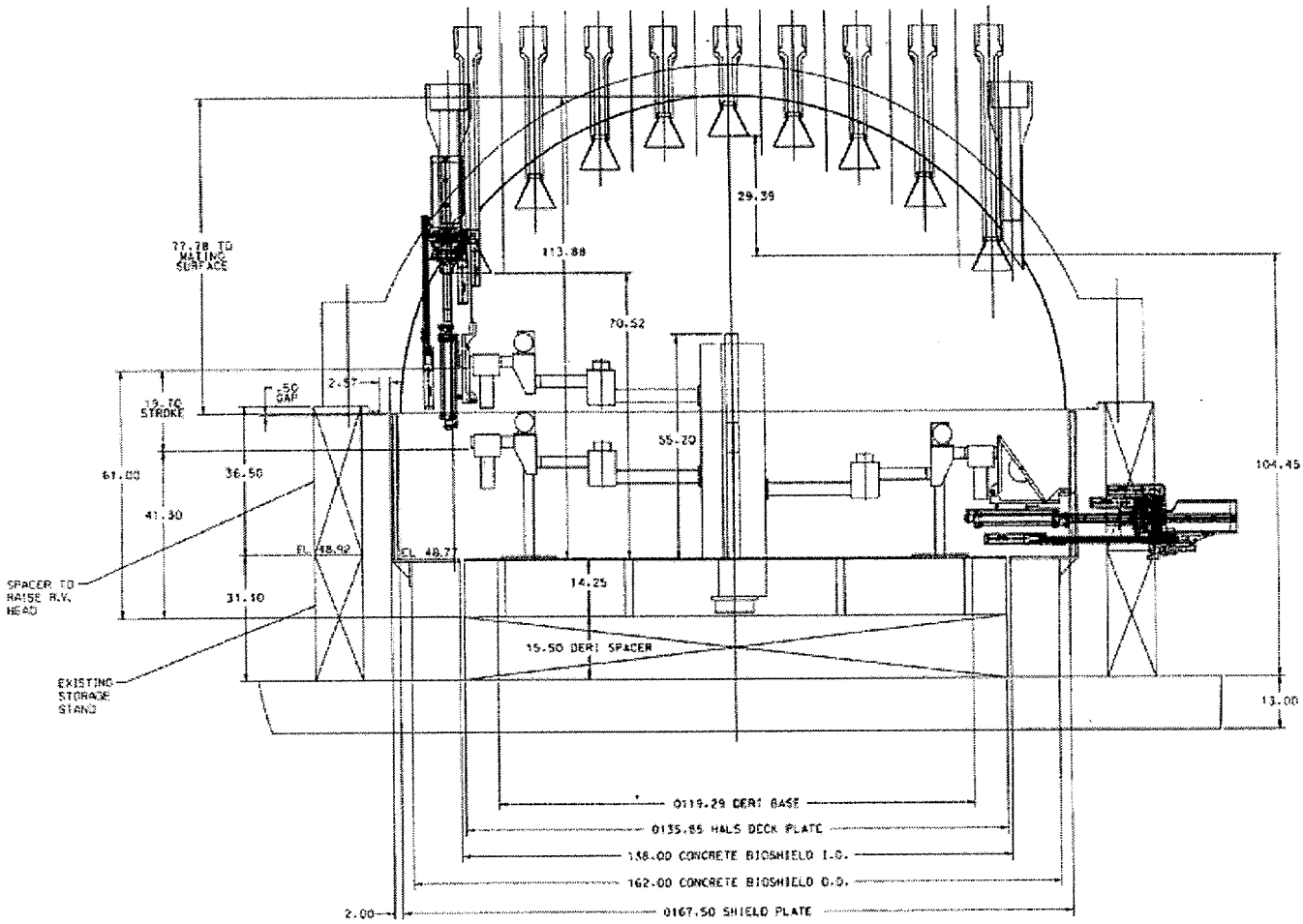
B. 10CFR50.55a(g)(5)(iii) states:

"If the licensee has determined that conformance with certain code requirements is impractical for its facility, the licensee shall notify the Commission and submit, as specified in 50.4, information to support the determinations."

10CFR50.55a(g)(6)(i) states:

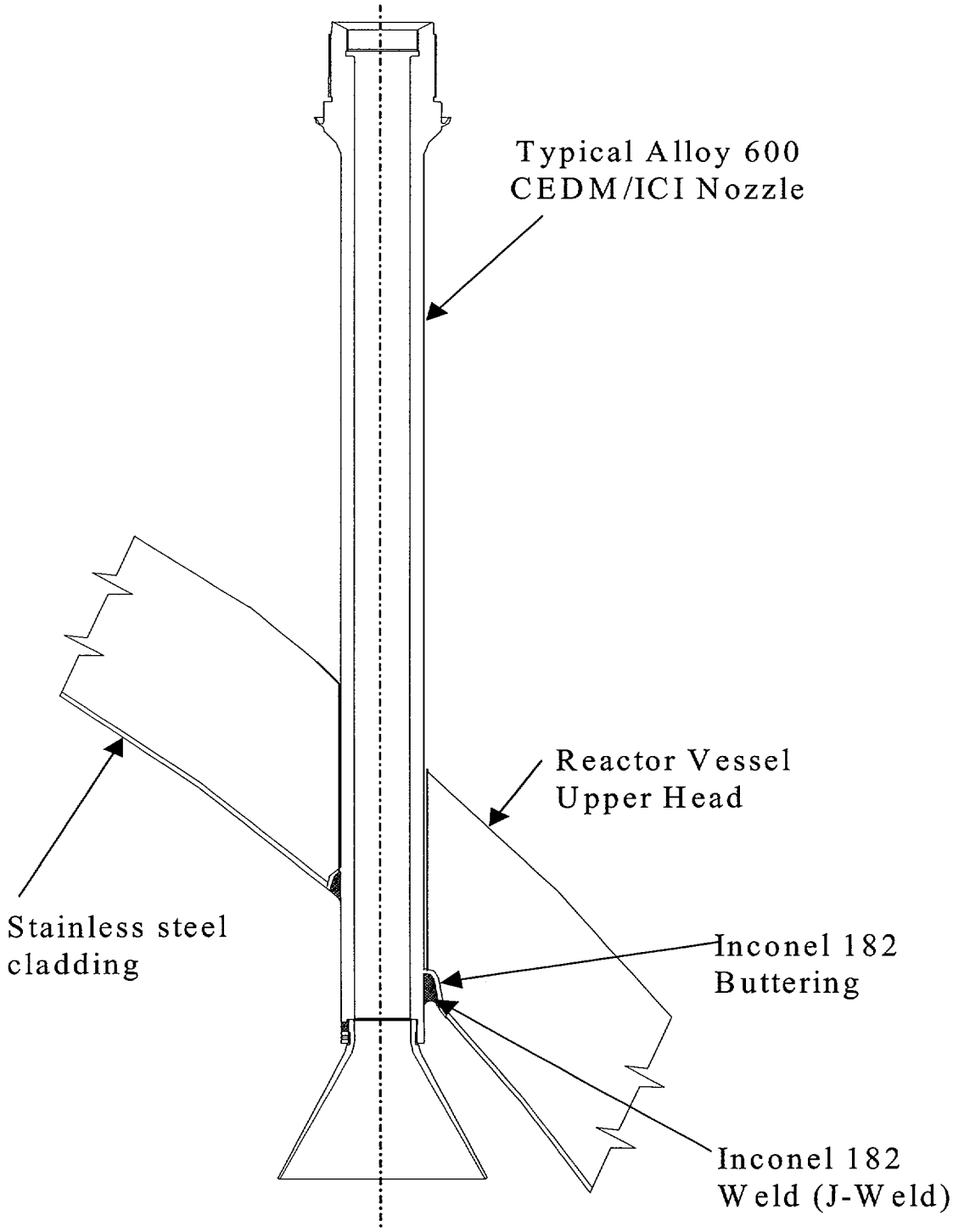
"The Commission will evaluate determinations under paragraph (g)(5) of this section that code requirements are impractical. The Commission may grant such relief and may impose such alternative requirements as it determines is authorized by law and will not endanger life or property or the common defense and security and is otherwise in the public interest giving due consideration to the burden upon the licensee that could result if the requirements were imposed on the facility."

Entergy believes the radiographic examination required by ASME Section III NB-2539.4 for base material weld repairs is impractical since it cannot be performed. Entergy has proposed an alternative examination (identified in Section III.B.2 and discussed in Section IV.C) that we believe provides an acceptable level of quality and safety. Therefore, Entergy requests relief from performing a radiographic examination and authorization to perform the proposed alternative examination pursuant to 10CFR50.55a(g)(6)(i).



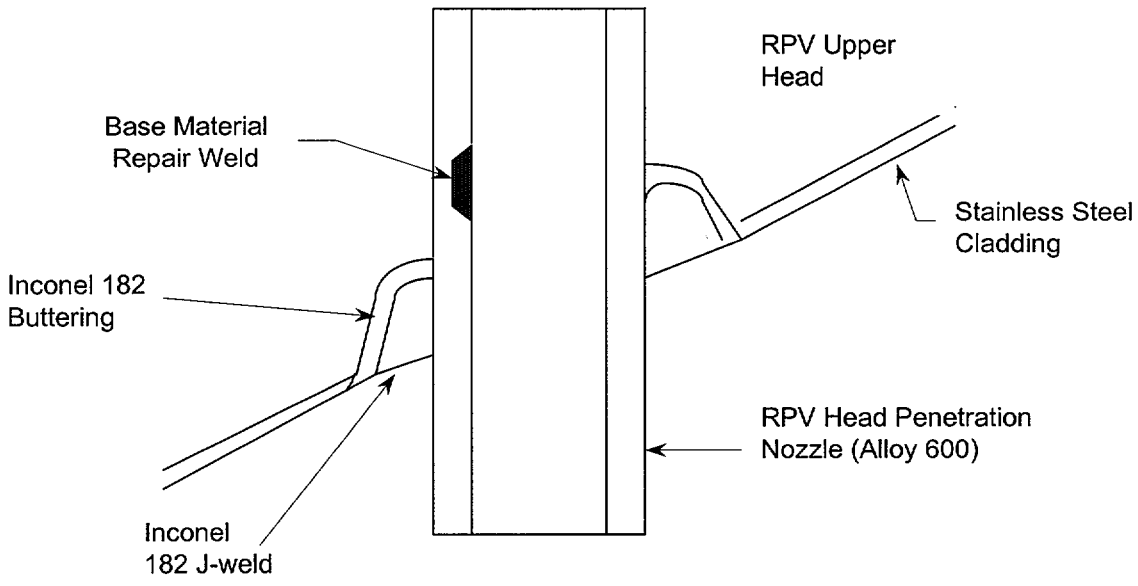
ANO-2 RPV HEAD PENETRATION NOZZLES

FIGURE 1



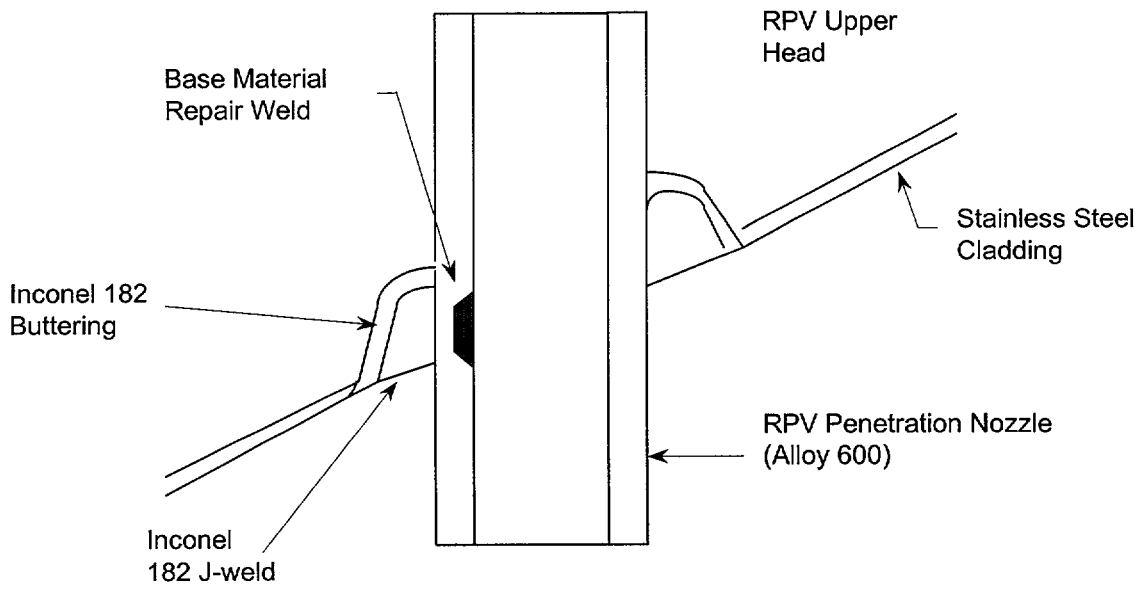
TYPICAL RPV HEAD PENETRATION NOZZLE

FIGURE 2



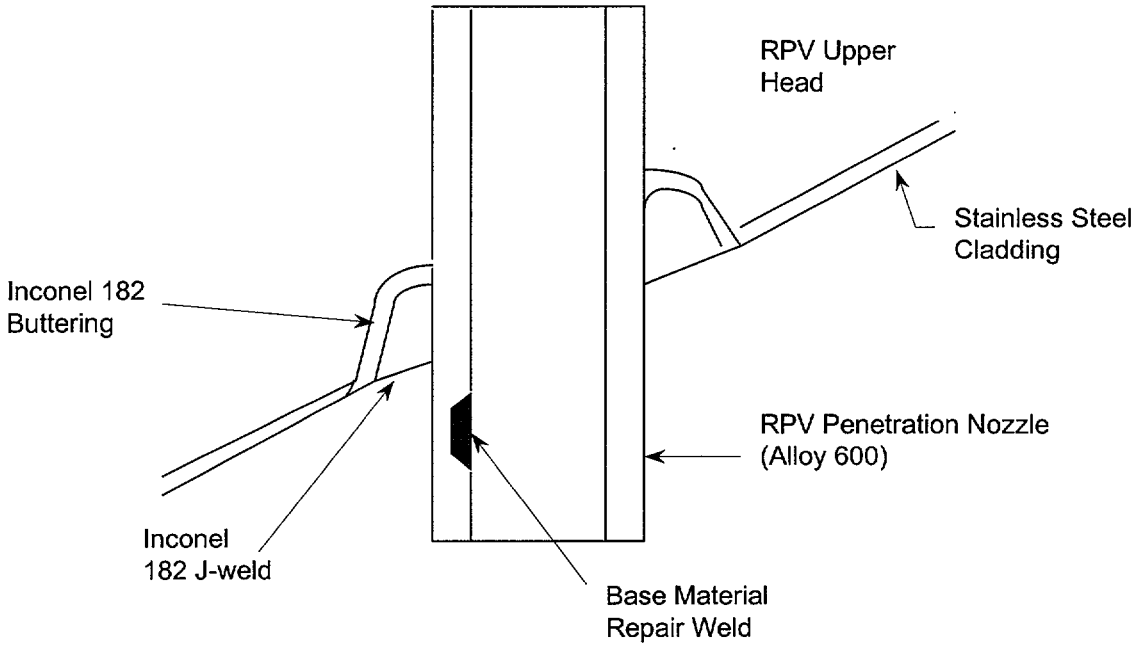
RPV Nozzle Repair Weld: Inside Diameter and Above J-Weld

FIGURE 3



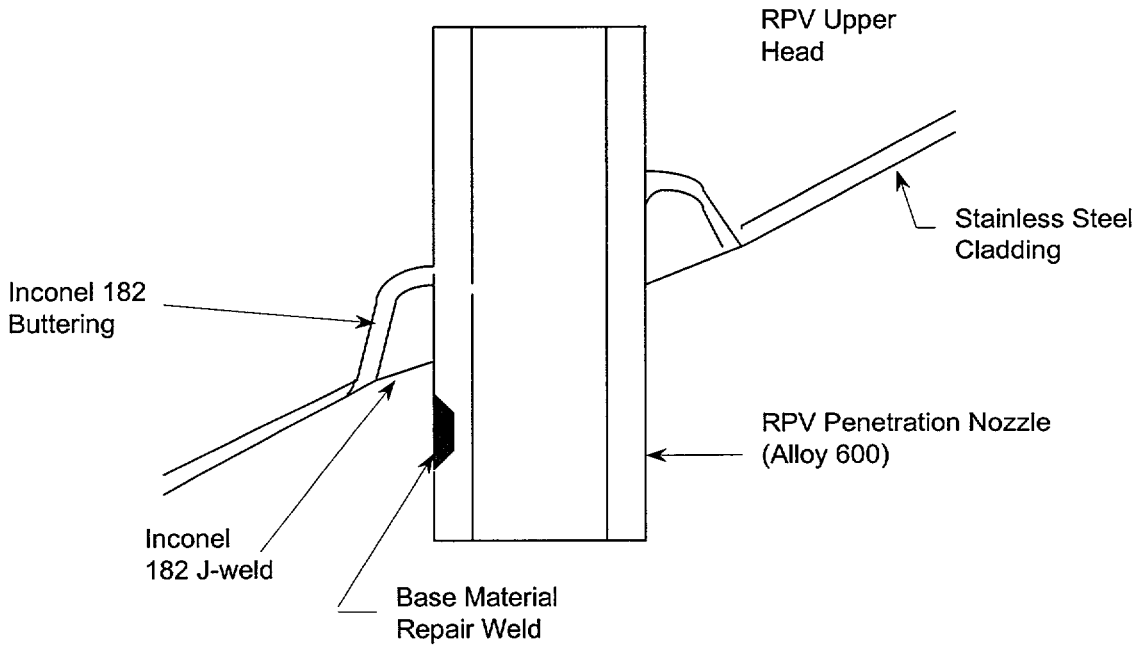
RPV Nozzle Repair Weld: Inside Diameter and Adjacent to J-Weld

FIGURE 4



RPV Nozzle Repair Weld: Inside Diameter and Below J-Weld

FIGURE 5



RPV Nozzle Repair Weld: Outside Diameter and Below J-Weld

FIGURE 6