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Michael A. Krupa
Director
Nuclear Safety & Licensing

CNRO-2002-00007

March 4, 2002

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

SUBJECT: Entergy Operations, Inc.
Proposed Alternative to ASME Examination Requirements for Repairs Performed on Reactor Vessel Head Penetrations

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

Dear Sir or Madam:

Pursuant to 10CFR50.55a(g)(5)(iii) and (g)(6)(i), Entergy Operations, Inc. (Entergy) requests 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. This request applies to Arkansas Nuclear One- Unit 2 (ANO-2).

As documented in Request No. ANO2-R&R-001, Rev. 0 (see enclosure), Entergy believes there is adequate evidence to determine that these examinations are impractical. In addition, Entergy proposes alternative examination methods to those specified in the Code.

Entergy plans to perform inspections of the outer base metal surface of the RPV nozzle penetrations for evidence of leakage during the upcoming refueling outage at ANO-2, which is scheduled to begin in April 2002. Currently, there is no evidence of leakage; however, we are submitting this request in order to proactively prepare for possible leaks that may be detected while performing these inspections.

Entergy requests that the NRC Staff approve ANO2-R&R-001 by April 19, 2002, in order to support inspection activities. ***Following NRC approval, Entergy will incorporate ANO2-R&R-001, Rev. 0 into the ANO-2 Inservice Inspection (ISI) Plan.***

This letter contains one commitment as denoted above in bold, italicized text.

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If you have any questions or require additional information, please contact Guy Davant at (601) 368-5756.

Sincerely,

MAK/GHD/baa

Enclosure:
1. Request No. ANO2-R&R-001

cc: Mr. C. G. Anderson (ANO)
Mr. W. R. Campbell (ECH)
Mr. J. K. Thayer (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 Regional Administrator, Region IV

**ENCLOSURE 1**

**REQUEST No. ANO2-R&R-001, Rev. 0**

**ENTERGY OPERATIONS, INC.**
**ARKANSAS NUCLEAR ONE - UNIT 2**
**3RD TEN-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<br>2. ASME Section III, Subsection NB, 1968 Edition, Summer 1970 Addenda<br>3. ASME Section III, Subsection NB, 1989 Edition<br>4. ASME Section III, Subsection NB, 1992 Edition, 1993 Addenda<br>5. CEP-ISI-004, "Arkansas Nuclear One Unit 2 Inservice Inspection Plan"<br>6. Letter 2CAN090102, "30 Day Response to NRC Bulletin 2001-01 for ANO-2; Circumferential Cracking of VHP Nozzles," dated September 4, 2001<br>7. American Society of Non-Destructive Testing document SNT-TC-1A, "Personnel Qualification and Certification in Non-Destructive Testing," 1984 Edition |
| Unit: | Arkansas Nuclear One – Unit 2 (ANO-2) |
| Inspection Interval: | Third ($3^{rd}$) 10-Year Interval |

## II. REQUIREMENTS

IWA-4170 of ASME Section XI, 1992 Edition states that repairs and the 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 ASME Section III, either in their entirety or portions thereof, and Code Cases may be used.

The original construction code for the ANO-2 reactor pressure vessel (RPV) is ASME Section III, Subsection NB, 1968 Edition, Summer 1970 Addenda. As allowed by ASME Section XI, repairs of the RPV penetration nozzles will be performed in

accordance with the 1989 Edition of ASME Section III. The applicable 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 below, the ANO-2 RPV 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 penetration nozzles.

- NB-2559

  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, repair welding of the RPV penetration nozzles is performed in accordance with NB-2539. However, 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 penetration nozzles can be performed in accordance with NB-2539 as clarified by the 1993 Addenda of ASME Section III.

- NB-2539.4

  Examination requirements for completed repair welds are specified in NB-2539.4. Repair weld examinations include a magnetic particle or liquid penetrant examination and possibly a radiographic examination, depending on the depth of the repair cavity. 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" 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 repair welding of the RPV penetration nozzles, the following supplemental requirements apply:

- IWA-4310

  "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)

"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 ALTERNATIVE

### A. Background

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

ANO-2's upcoming refueling outage is scheduled to begin in April 2002. During this refueling outage, examination of RPV penetration nozzles will be performed as described in ANO-2's response to NRC Bulletin 2001-01 (Reference 6).

In the event inspection results require repairs to the nozzle base material, the requirements of the Construction Code and ASME Section XI, as described in Section II, provide an impracticality for which relief is requested. To further clarify the requirements, a typical base material repair scenario is provided below demonstrating the various examination sequences required by the Construction

Code and ASME Section XI. Section III.B provides the proposed alternatives to examination of the excavated area and radiography of the final repair weld.

Typical Base Material Repair

Base material weld repairs of RPV penetration nozzles are performed to re-establish the structural integrity of RPV penetration nozzles as described in Section II above. Base material weld repairs typically include the following basic steps:

- **Defect Removal**: PWSCC cracks are either removed or reduced to an acceptable size in accordance with IWA-4310.

- **Repair Cavity Examination**: Magnetic particle or liquid penetrant examinations of repair weld cavities are performed prior to welding in accordance with IWA-4331(a). However, where a portion of the flaw is left in the repair cavity, a liquid penetrant examination cannot be performed. Examination materials trapped in the as-left flaw could have a deleterious effect on the repair welds.

- **Repair Welding**: Repair welding is performed in accordance with applicable requirements of ASME Section XI and ASME Section III, NB-2500.

- **Examination of Repair Welds**: Repair welds of RPV 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" or 10% of the section thickness, a radiographic examination of the repair weld is also required by NB-2539.4. However, due to the thickness, size, and complex geometry of the RPV head in the RPV penetration nozzle locations, radiographic examination of repair welds is impractical.

## B. Proposed Alternatives

Pursuant to the provisions of 10CFR50.55a(g)(5)(iii), Entergy requests relief from performing examinations of base material weld repairs made to RPV nozzles as required by ASME Section XI IWA-4331(a) and Section III NB-2539.4. Entergy proposes the following alternative examinations:

1. 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 the alternative described below.

   a) **Flaw Characterization**: Prior to repair welding, RPV penetration nozzles will be examined by the ultrasonic and eddy current or liquid penetrant examination method to characterize all flaws.

   b) **Flaw Evaluation**: All flaws in RPV 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.

c) **Examination of Repair Weld**: Upon completion of welding, the repair weld will be ultrasonically examined to verify that the as-left dimensions of the flaw comply with the acceptance limits. A liquid penetrant or eddy current examination of the completed repair weld will also be performed.

2. As an alternative to the radiographic examination requirement of ASME Section III NB-2539.4 when the depth of the repair cavity exceeds the lesser of 3/8" or 10% of the section thickness, Entergy proposes to perform ultrasonic and eddy current examinations of the completed repair weld.

## IV. BASIS FOR DETERMINING IMPRACTICALITY AND SUITABILITY OF PROPOSED ALTERNATIVES

### A. IWA-4331(a)

IWA-4331(a) of ASME Section XI requires a magnetic particle or liquid penetrant examination of all repair cavities prior to repair welding. However, where a portion of the flaw is left in the repair cavity of the RPV penetration nozzle, a liquid penetrant examination of the repair cavity cannot be performed. Entergy's proposed alternative is described in Section III of this relief request. The basis for this alternative is provided in the following paragraphs.

Impracticality of Repair Cavity Surface Examinations

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 penetration nozzles are manufactured from SB-166 and SB-167 nickel alloys which are not magnetic. Therefore, examination of repair weld cavities in RPV penetration nozzles by the magnetic particle method is not possible.

Liquid penetrant testing is a nondestructive method that reveals open-surface discontinuities by bleedout 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 penetration nozzle is required, liquid penetrant would be the appropriate examination method.

A liquid penetrant examination of repair cavity surfaces is allowed by IWA-4331(a) as an alternative to magnetic particle examination. However, the repair cavity surfaces must also exhibit a high state of cleanliness prior to welding. According to NB-4412, "The surfaces for welding shall be free of scale, rust, oil, grease, and other deleterious material. The surfaces for welding shall be protected from deleterious contamination and from rain, snow, and wind during welding. Welding

shall not be performed on wet surfaces." When a portion of a flaw is left in the repair cavity, liquid penetrant examination materials could become trapped in the as-left flaw. Trapped examination materials would be consumed during the welding process. As contaminants, the examination materials could cause cracks and other unacceptable weld defects.

ASME Section XI recognizes the deleterious affects of examination materials remaining on a weld. According to IWA-4331(a), "This examination is not required when defect elimination removes the full thickness of the weld and backside of the weld joint is not accessible for removal of examination materials." This exemption also exists in NB-4453.1 of ASME Section III. While ASME Section XI fundamentally recognizes the deleterious affect of examination materials on a weld, it does not specifically include the as-left flaw condition in its exemption. Nonetheless, the affect of examination materials remaining on a repair weld are the same regardless of whether the examination materials are trapped in the weld root or an as-left flaw.

Suitability of Proposed Alternative

A surface examination is performed on a weld cavity to ensure that cracks and other unacceptable defects have been removed. 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, described in Section III above, ensures that structural integrity of the RPV penetration nozzle repair welds is maintained by:

- Thorough examinations
- Complete removal or reducing flaws to an acceptable size prior to welding
- Performing ultrasonic and liquid penetrant or eddy current examinations on repair welds.

**B. NB-2539.4**

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" 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 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 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 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 penetration nozzle repair welds impractical.

Suitability of Proposed Alternative

Radiographic examination of repair welds is performed to verify weld soundness. According to NB-2539.4, a radiographic examination of repair welds is required whenever the depth of the repair cavity exceeds the lesser of 10% of the section thickness or 3/8". However, as explained above, radiographic examination of base material repair welds using the radiographic method is impractical. As an alternative, Entergy proposes to perform ultrasonic and eddy current examinations of the completed repair weld.

The ultrasonic examination method is a nondestructive method in which beams of high frequency sound waves are introduced into an object to detect and locate surface and internal discontinuities. Sound beams that are directed into the object on a predictable path are reflected at interfaces and other interruptions in material continuity. The reflected beam is detected and analyzed to define the presence and location of discontinuities.

The ultrasonic examinations will provide a 100% volumetric examination of the repair area using a combination of straight and angle beam techniques. Capabilities of the techniques will be demonstrated on a representative sample simulating the repair weld condition. The angle beam examinations will be conducted in two opposing directions, perpendicular and parallel to the repair weld, for detection of reflectors parallel and transverse to the repair weld. The ultrasonic examination method will provide detectability of planar defects of a size and orientation equivalent to that of radiography. Personnel performing these examinations shall be qualified and certified using a written practice prepared in accordance with SNT-TC-1A (Reference 7).

Eddy current examinations will also be conducted. The eddy current inspection will complement the ultrasonic examination by providing sensitivity to subsurface flaws near the inspection surface. This technique has been used in field applications for examinations of RPV penetration nozzles, J-welds, and Alloy 182 safe end welds. Personnel performing these examinations shall be qualified and certified using a written practice prepared in accordance with SNT-TC-1A.

## V. CONCLUSION

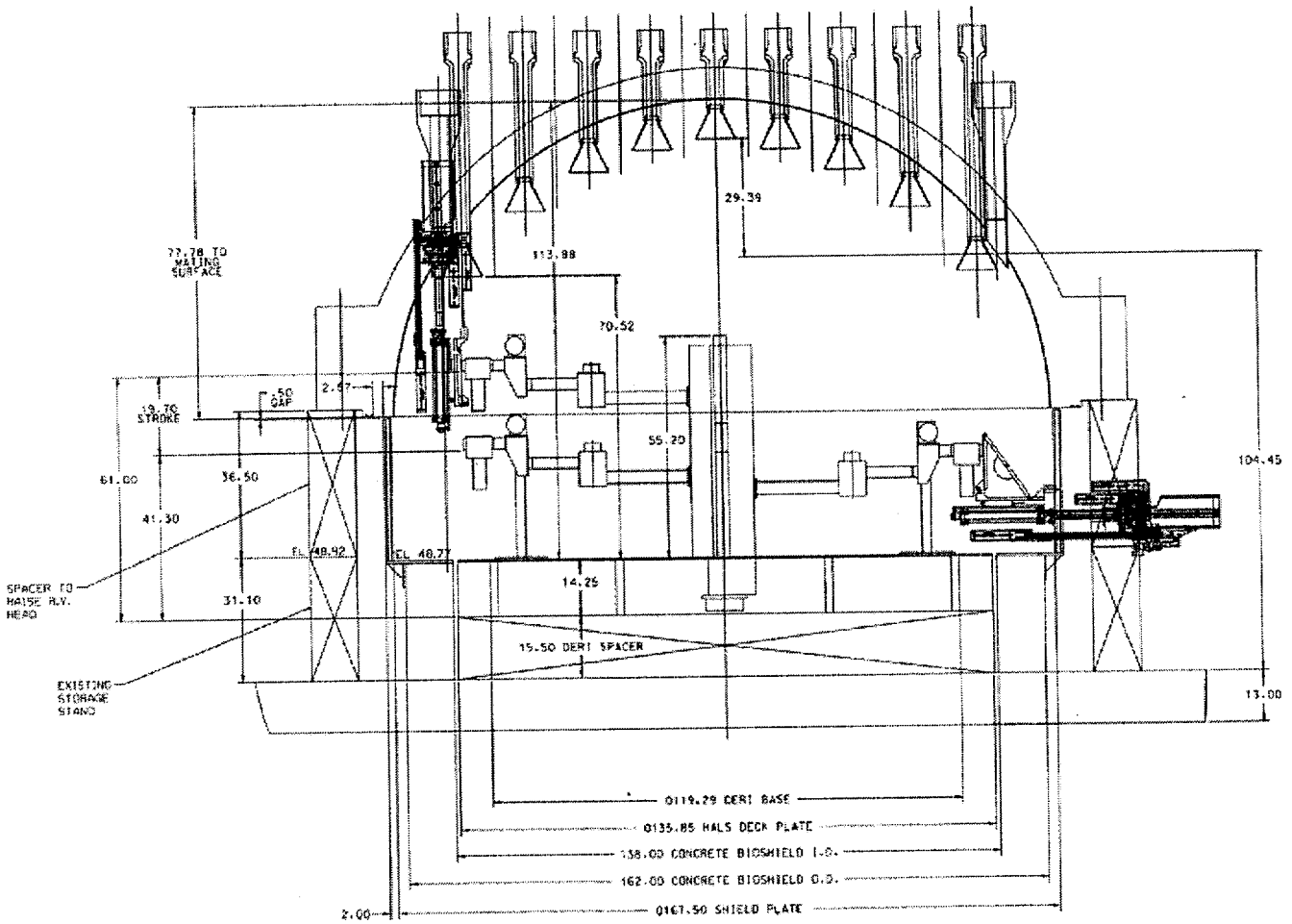
10CFR50.55a(g)(5)(iii) states:

"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:

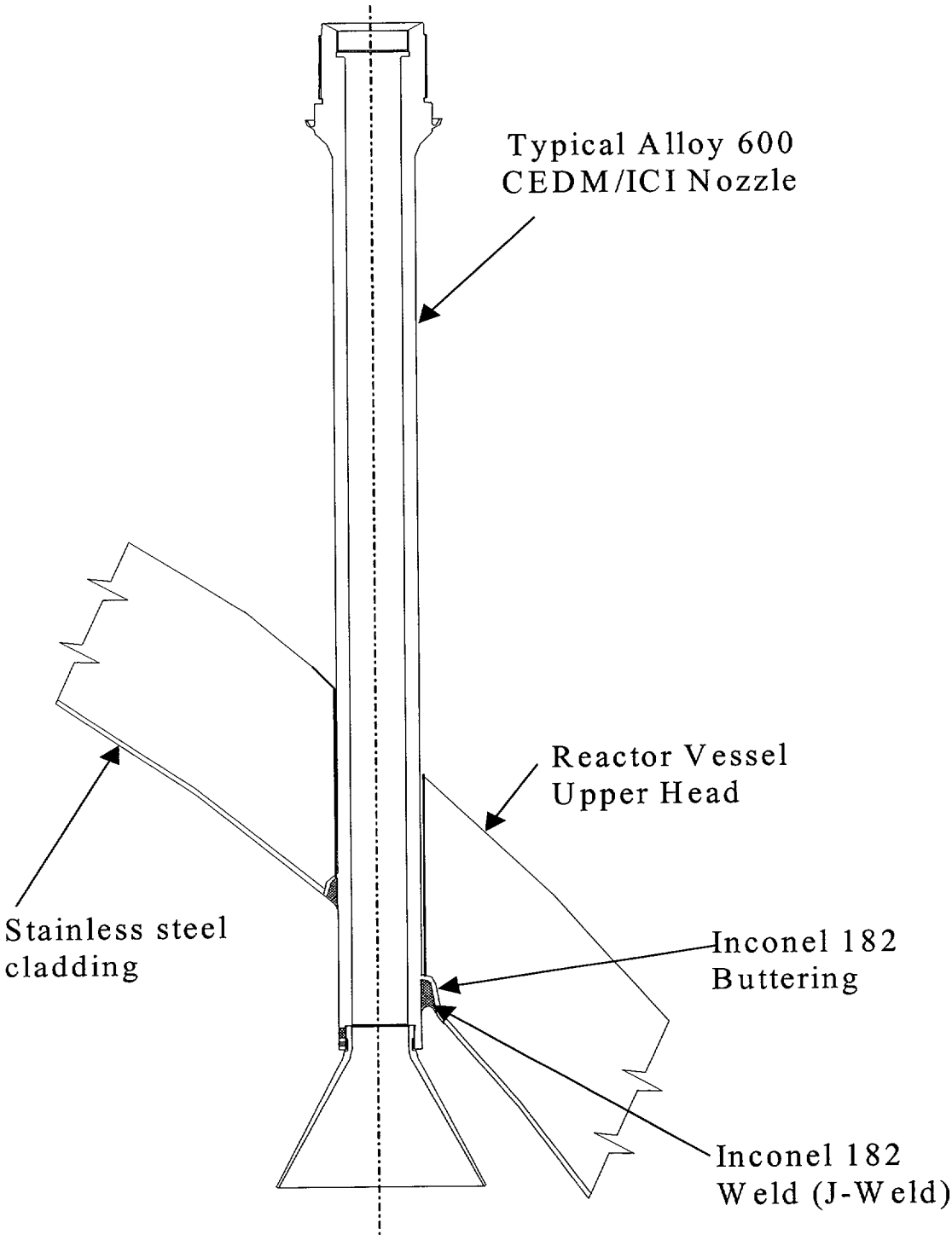
"The Commission will evaluate determinations under paragraph (g)(5) of this section that code requirements are impractical. The Commission may grant such relief and may impose such alternative requirements as it determines is authorized by law and will not endanger life or property or the common defense 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."

As discussed in this request, Entergy believes the examinations required by ASME Section XI IWA-4331(a) and Section III NB-2539.4 for base material weld repairs are impractical since they cannot be performed. Entergy has proposed alternative examination methods that we believe provide an acceptable level of quality and safety. Therefore, we request the proposed request for relief be authorized pursuant to 10CFR50.55a(g)(6)(i).




**ANO-2 RPV PENETRATION NOZZLES**

**FIGURE 1**




**TYPICAL RPV PENETRATION NOZZLE**

**FIGURE 2**