



Entergy Operations, Inc.
1340 Echelon Parkway
Jackson, MS 39213-8298
Tel 601 368 5758

Michael A. Krupa
Director
Nuclear Safety & Licensing

CNRO-2002-00022

August 2, 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 Alternatives to ASME Requirements for Weld Repairs (TAC
Nos. MB4286, MB4288, and MB4289)

Arkansas Nuclear One, Units 1 and 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6

Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

- REFERENCES:**
1. Entergy Operations, Inc. Letter Nos. CNRO-2002-00008 and CNRO-2002-00017 from Entergy Operations, Inc., to the NRC, "Proposed Alternative to ASME Code Requirements for Weld Repairs," dated March 4, 2002, and March 29, 2002, respectively
 2. Letters from the NRC to Entergy Operations, Inc., "Arkansas Nuclear One, Units 1 and 2, and Waterford Steam Electric Station, Unit 3 – Request for Additional Information Regarding Proposed Alternatives to American Society of Mechanical Engineers Boiler and Pressure Vessel Code Requirements for Weld Repairs (TAC Nos. MB4288, MB4289, and MB4286)," dated March 28, 2002, and April 18, 2002, respectively

Dear Sir or Madam:

In correspondence noted in Reference #1, Entergy Operations, Inc., (Entergy) proposed to the NRC staff an alternative method to the temper bead welding requirements of ASME Section XI IWA-4500 and IWA-4530. This request, submitted as Request for Alternative PWR-R&R-001, Rev. 0, is applicable to Arkansas Nuclear One (ANO), Units 1 and 2, and Waterford Steam Electric Station, Unit 3 (Waterford 3).

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During the course of review, the NRC staff determined that additional information is necessary to complete its review; therefore, the staff transmitted two Requests for Additional Information (RAIs) to support its review and approval of PWR-R&R-001 (see Reference #2). Entergy's responses to these RAIs are contained in Enclosures 1 and 2.

As a result of the responses to the RAIs, Entergy has revised PWR-R&R-001, Rev. 0. This revised request is contained in Enclosure 3 and supercedes the previous request submitted to the NRC staff via Reference #1.

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

This letter contains no new commitments.

Very truly yours,

 for MAK

MAK/GHD/baa

Enclosures:

1. Response to NRC Request for Additional Information Pertaining to Request No. PWR-R&R-001, Rev. 0 (TAC Nos. MB4286, MB4288, and MB4289) dated March 28, 2002
2. Response to NRC Request for Additional Information Pertaining to Request No. PWR-R&R-001, Rev. 0 (TAC Nos. MB4286, MB4288, and MB4289) dated April 18, 2002
3. Request No. PWR-R&R-001, Rev. 0

cc: Mr. C. G. Anderson (ANO)
Mr. W. R. Campbell (ECH)
Mr. J. E. Venable (W3)
Mr. G. A. Williams (ECH)

Mr. T. W. Alexion, NRR Project Manager (ANO-2)
Mr. R. L. Bywater, NRC Senior Resident Inspector (ANO)
Mr. M. C. Hay, NRC Senior Resident Inspector (W3)
Mr. N. Kalyanam, NRR Project Manager (W3)
Mr. E. W. Merschoff, NRC Region IV Regional Administrator
Mr. W. D. Reckley, NRR Project Manager (ANO-1)

ENCLOSURE 1

CNRO-2002-00022

**RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
PERTAINING TO REQUEST No. PWR-R&R-001, Rev. 0
(TAC Nos. MB4286, MB4288, and MB4289) DATED MARCH 28, 2002**

**RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
PERTAINING TO REQUEST No. PWR-R&R-001, Rev. 0
(TAC Nos. MB4286, MB4288, and MB4289) DATED MARCH 28, 2002**

1. The request for relief must state the specific paragraphs / subparagraphs / sentences etc., affected by the proposed alternative, state the proposed alternative for each paragraphs/subparagraphs/sentences/etc, and provide a basis and justification for proposed alternative to the specific paragraphs/subparagraphs/sentences. (Any requirement not listed in the "Requirements for which Relief is Requested" is presumed to be met in their entirety). Approval of a process or technique is not an implied approval of requirements not contained in the "Requirements for which Relief is Requested." A process or technique must satisfy all aspects of the Code except for the specific requirements stated in the "Requirements for which Relief is Requested." For example, Page 2 and 3, lists bullets that appear to be from the Code but are not identified as complying with all the requirements in Code. Also the proposed temper bead technique in Attachment 1 [of PWR-R&R-001] appears to have differences from Code that are not identified in the "Requirements for which Relief is Requested" part of the submittal.

Please provide the above requested information. In formulating the response to this question, the staff refers you to Surry's submittals of October 30, 2001 as supplemented December 3, 2001, and Davis Besse's submittal of January 11, 2001. Although the submittal referenced the Surry submittal dated October 30, 2001, the "Requirements for which Relief is Requested" section lacked specificity which was carried through the entire submittal. Each application must stand on its own.

Response to Item 1

Entergy has included in pages 4 through 6 of revised Request PWR-R&R-001 (see Enclosure 3) a comparison between current Code requirements and proposed alternatives, as applicable. Where there are differences, Entergy has proposed alternatives. The suitability of the proposed alternatives is addressed in pages 10 through 13 of revised PWR-R&R-001.

2. Part I: Page 3 [of PWR-R&R-001] discusses Electric Power Research Institute (EPRI) Report GC-111050. The EPRI report provided general comments of possible effects from post weld heat treatment. Because they are general, they do not provide a basis for not performing a Section III repair. The same report also discussed comparison testing with and without heat treatment and made no mention of distortion. The implications by the submittal that heat treatment is the cause of thermal stress or creates more stress than a weld repair is not substantiated by the EPRI report. Other utilities have performed similar repairs to the RPV head with post and preheat treatments without experiencing the difficulties mentioned in the submittal.

Response to Item 2, Part I

Request PWR-R&R-001 proposes an alternative to the machine or automatic gas tungsten arc welding (GTAW) temper bead process of IWA-4500 and IWA-4530. It does not propose an alternative to the repair welding rules of ASME Section III (NB-4600). To clarify the request, Entergy has deleted discussion of postweld heat treatment from Section II, REQUIREMENTS, of PWR-R&R-001. Entergy has also clarified the discussion pertaining to EPRI Report GC-111050, Ambient Temperature Preheat for Machine GTAW Applications, on page 7 of revised PWR-R&R-001.

2. Part II: Please explain why Section III of the Code or alternatives to Section III (NB-4622.11) are not applicable or explain why the repair cannot be performed according to Section III or alternatives to Section III.

Response to Item 2, Part II

The reactor pressure vessel (RPV) heads are manufactured from P-Number 3, Group 3 low alloy steels. If repairs are performed in accordance with ASME Section III, Entergy would have two options: (1) perform a weld repair that includes a postweld heat treatment (PWHT) at 1100°F – 1250°F in accordance with NB-4622.1; or (2) perform a temper bead repair using the shielded metal arc welding (SMAW) process in accordance with NB-4622.11. Each option is discussed below.

- (1) *PWHT of the RPV head is an impractical option that would have undesirable effects. ASME Section III NB-4600 requires PWHT to be performed at 1100° - 1250°F. To the best of Entergy's knowledge, an ASME Section III PWHT of a completed RPV head has never been performed. PWHT of the RPV head could result in ovalization of penetrations, changes in clearances, and misalignment of tubes. Section 2.1 of EPRI Report GC-111050 states, "Localized heat treatments are extremely difficult to facilitate and often can produce undesirable side effects in terms of component distortion, thermal stresses and material degradation attendant to such procedures."*
- (2) *NB-4622.11 provides temper bead rules for repair welding of dissimilar materials using the SMAW process. Because NB-4622.11 does not include temper bead rules for the machine or automatic Gas Tungsten Arc Welding (GTAW) process, a manual temper bead process must be used. However, a manual SMAW temper bead repair is not a desirable option due to radiological considerations. First of all, scaffolding must be built and resistant heating blankets, thermocouples, and insulation must be installed. Secondly, the manual SMAW temper bead welding process is a time and dose intensive process. Each weld layer is manually deposited in a high dose and high temperature (350°F) environment. The manual SMAW temper bead process of NB-4622.11 also requires that the weld crown of the first weld layer be mechanically removed by grinding. Upon completing repair welding, resistant heating blankets, thermocouples, insulation, and scaffolding must be removed. Thermocouples and heating blanket mounting pins must be removed by grinding. Ground areas must be subsequently examined by the magnetic particle or liquid penetrant examination method.*

Entergy estimates that the dose associated with an SMAW temper bead repair on the RPV head to be at least 20 REM per weld repair. In addition, Entergy estimates the dose associated with the set-up and disassembly of the elevated preheat and postweld soak to be at least 15 REM.

Entergy has not requested an alternative to NB-4622.11; rather, PWR-R&R-001 proposes an alternative to IWA-4500 and IWA-4530. Owners are allowed by ASME Section XI IWA-4170(b) and IWA-4500(a) to perform temper bead repairs of dissimilar materials. IWA-4170(b) and IWA-4500(a) provide requirements and controls for performing such repairs.

- 2a. Page 3, the gas tungsten arc welding (GTAW) process described on page 3 does not meet the criteria in IWA-4500 or NB-4622.11. Please identify the specific subparagraphs/sentences of the Code that the repair will not meet. Also, identify the alternative that will be used in lieu of Code requirements and provide the justification/bases to support the alternative.

Response to Item 2a

Entergy has not requested an alternative to ASME Section III NB-4622.11; rather, PWR-R&R-001 proposes an alternative to ASME Section XI IWA-4500 and IWA-4530. Entergy included in pages 4 through 6 of revised PWR-R&R-001 a comparison between current Code requirements of IWA-4500 and IWA-4530 and proposed alternatives, as applicable. Where there are differences, Entergy has proposed alternatives. The suitability of the proposed alternatives is addressed in pages 10 through 13 of PWR-R&R-001.

- 2b. Both IWA-4533 and NB-4622.11(d) require radiographic testing (RT) examination after completion of the repair. The submittal does not address RT examinations of the repaired weldment. Because of the absence of RT in the "Requirements for which Relief is Requested," the staff presumes that RT will be performed. Other licensees have asked for relief from RT examinations. If RT will be performed, provide a discussion on how this will be accomplished. If RT will not be performed, it should be specified in the "Requirements for which Relief is Requested" and accompanied with the proposed alternative and justification/bases.

Response to Item 2b

Entergy has not requested an alternative to NB-4622.11; rather, PWR-R&R-001 proposes an alternative to IWA-4500 and IWA-4530. Entergy has included on pages 4 through 6 of revised PWR-R&R-001 a comparison between current Code requirements of IWA-4500 and IWA-4530 and proposed alternatives, as applicable. Entergy has also deleted temper bead repairs of RPV head penetration nozzle base material from PWR-R&R-001. Entergy specifically addresses RT as required by IWA-4533 on pages 6, 13, 16, and 17 of revised PWR-R&R-001.

3. In Attachment 1, Section 4.0 "Examination" of the submittal, surface and ultrasonic examination methods for the machined surface prior to repair and after welding is discussed.
- a) Please provide sketches showing the area that will be surface inspected prior to welding and after welding. Indicate any differences in the inspection areas (from Code requirements) for the instrument nozzles, head vent nozzle, and control element drive mechanism nozzles.
 - b) Please provide sketches showing the examination surface and volume required by Code for each inspection method and show the actual surface and volume that will be inspected. Describe the percent of coverage that will be achieved for each transducer and the total coverage for each repair.

Response to Items 3a and 3b

Entergy has provided sketches depicting a typical RPV head penetration nozzle (Figure 1) and an example repair of an RPV head penetration nozzle J-weld (Figure 2) in revised PWR-R&R-001. Entergy has deleted temper bead repairs of RPV head penetration nozzle base material from PWR-R&R-001.

- c) Please describe to what criteria will the ultrasonic testing (UT) examinations be performed? (In accordance with criteria of Section III, Appendix VIII of Section XI, Appendix III of Section XI, or Section V?)

Response to Item 3c

Entergy will not perform base material repairs in RPV head penetration nozzles, as previously requested. Entergy has deleted this discussion from PWR-R&R-001. The proposed examination for the J-weld is progressive liquid penetrant testing (PT) in accordance with NB-5245 of ASME Section III.

- d) If UT will be used in lieu of a Section III RT, provide a comparison (advantages, disadvantages, detection sensitivity for different types of flaws, etc) of the different characteristic between the methods.
 - i) For UT examination, please describe the differences between a Section III and Section XI UT examination. The description should compare paragraphs/figures/tables with a proposed reconciliation. Items that should be included in the description are examination volume, examination coverage (scanning directions and transducers characteristics) and acceptance criteria.
 - ii) Include in the discussion any demonstrations performed on mock-ups and the types of flaws in the mock-up which demonstrates that the effectiveness of the UT in detecting construction repair related flaws. Are the flaws comprised of representative examples of flaws common to fabrication?
 - iii) Discuss any inspection anomalies and assumptions associated with the UT technique.

Response to Item 3d

Entergy will not perform temper bead base material repairs in RPV head penetration nozzles, as previously requested. Entergy has deleted this discussion from PWR-R&R-001.

4. Please provide a discussion and cross-sectional sketch of the weld repair.

Response to Item 4

Entergy has provided sketches depicting a typical RPV head penetration nozzle (Figure 1) and an example repair of an RPV head penetration nozzle J-weld (Figure 2) in revised PWR-R&R-001.

5. Provide a technical justification for granting relief from a welding process standpoint, to show that quality temper bead welds can be made with an ambient temperature automatic or machine gas tungsten arc welding (GTAW) temper bead process. This should include procedure qualification and other test data that make it clear from these results that the machine GTAW temper bead process has the capability of producing acceptable repair welds. These data should show acceptability from notch toughness test results as well as tensile and bend test results.

Response to Item 5

Entergy has provided the requested information in Section IV, BASIS FOR PROPOSED ALTERNATIVE, of revised PWR-R&R-001.

6. The Relief Request needs to detail the methods to be used for monitoring maximum interpass temperature for the welding. If there is a justification for not using thermocouples for temperature measurement, then this justification needs to be detailed in the Relief Request.

Response to Item 6

Entergy has provided the requested information on page 10 of revised PWR-R&R-001.

7. The Relief Request needs to detail the base metals, i.e., P-numbers, and filler metal classification to be used in these repairs. According to Code both of the base metals in a dissimilar weld shall be qualified by test in which the base metals have been welded to each other and tested in accordance with ASME Section IX and the relief request.

Response to Item 7

Entergy provided the requested information on pages 13 and 23 of revised PWR-R&R-001.

8. Using the 1992 Edition of Section XI, IWA-4170 (b) "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. If repair welding cannot be performed in accordance with these requirements, the applicable requirements of IWA-4200, IWA-4400, or IWA-4500 may be used."

Please provide an explanation as to why the repair cannot be performed according to Section III. If an alternative to IWA-4000 was determined necessary, explain why the repair should not be performed according to Section III requirements and an alternative requested from section III.

Response to Item 8

See the response to Item #2, above, for an explanation of why repair welding cannot be performed in accordance with ASME Section III.

ASME Section III is a Construction Code that establishes requirements pertaining to the materials, design, fabrication, examination, testing, and stamping of new ASME Class 1, 2, and 3 components such as vessels, piping, pumps, and valves. The rules of ASME Section III apply to new construction only. ASME Section XI is an Inservice Inspection Code that establishes rules for performing repair and replacement activities on ASME Class 1, 2, and 3 components in operating nuclear power plants. According to IWA-1200 of ASME Section XI, "The jurisdiction of this Division covers individual components and complete plants that have met all the requirements of the Construction Code, commencing at that time when the Construction Code requirements have been met." Therefore, repair and replacement activities must be performed in accordance with ASME Section XI. The Construction Code or ASME Section III can only be used as invoked by ASME Section XI.

IWA-4170(b) of the 1992 Edition of Section XI 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. If repair welding cannot be performed in accordance with these requirements, the applicable requirements of IWA-4200, IWA-4400, or IWA-4500 may be used."

Because a Construction Code such as ASME Section III was written for new construction and not an operating nuclear power plant, Construction Code rules do not necessarily consider the radiological and repair challenges facing an Owner. This being the case, IWA-4170(b) is intended to provide an Owner with repair welding alternatives that may not be included in the Construction Code. Entergy does not believe that IWA-4170(b) is intended to require an Owner to comply with original Construction Code rules that are impractical or result in high radiological exposure when the alternatives in IWA-4200, IWA-4400, and IWA-4500 provide more suitable repair processes and methods. This point was clarified in the 1995 Addenda of the 1995 Edition of ASME Section XI as follows:

- *IWA-4410(a) - "Repair/replacement activities shall be performed in accordance with the Owner's Requirements and the original Construction Code of the component or system, except as provided in IWA-4410(b), (c), and (d)."*
- *IWA-4410(b) - "Later Editions and Addenda of the Construction Code or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used..."*
- *IWA-4410(c) - "Alternatively, the applicable requirements of IWA-4600 (i.e. temper bead welding methods) may be used for welding, and the applicable requirements of IWA-4700 may be used for heat exchanger tube plugging and sleeving."*
- *IWA-4410(d) - "Revised Owner's Requirements may be used provided they are reconciled in accordance with IWA-4222. A Report of Reconciliation shall be prepared."*

In conclusion, Entergy believes that IWA-4170(b) allows an Owner to perform a temper bead repair in accordance with IWA-4500. Entergy also believes that this is consistent with 10CFR50.55a in that the NRC did not take any exceptions to this requirement in 10CFR50.55a.

9. *IWA-4170(a) states that, "The edition and addenda of Section XI used for the repair/replacement program will correspond with the edition and addenda identified in the inservice inspection program applicable to the inspection interval. Alternatively later editions and addenda of Section XI, either in their entirety or portions thereof, may be used for the repair/replacement program, provided these editions and addenda of Section XI at the time of the planned repair or replacement are acceptable to the enforcement and regulatory authorities having jurisdiction at the plant site."*

Please provide an explanation for selecting portions (sentences) from Code and not address 50.55a(g)(4)(iv) [which] states that "ISI [Inservice Inspection] of components and system pressure tests may meet the requirements set forth in subsequent editions and addenda that are incorporated by reference in paragraph (b) of this section, subject to the limitations and modifications listed in paragraph (b) of this section, and subject to Commission approval. Portions of editions or addenda may be used provided that all related requirements of the respective editions or addenda are met."

Response to Item 9

Entergy performs repair and replacement activities in accordance with the 1992 Edition of ASME Section XI. IWA-4170(a) states:

"The edition and addenda of Section XI used for the repair/replacement program will correspond with the edition and addenda identified in the inservice inspection program applicable to the inspection interval. Alternatively later editions and addenda of Section XI, either in their entirety or portions thereof, may be used for the repair/replacement program, provided these editions and addenda of Section XI at the time of the planned repair or replacement are acceptable to the enforcement and regulatory authorities having jurisdiction at the plant site."

10CFR50.55a(b)(2) states, "As used in the section, references to Section XI of the ASME Boiler and Pressure Vessel Code refer to Section XI, Division 1, and include editions and addenda through the 1996 Addenda, subject to the following limitations..."

10CFR50.55a(b)(2) also specifies limitations and modifications on the use of specific editions and addenda of ASME Section XI. When using an NRC-approved edition and addendum of ASME Section XI, the Owner must comply with the limitations and modifications applicable to the specific edition and addendum of ASME Section XI. However, 10CFR50.55a(b)(2) does not include limitations, restrictions, or modifications to paragraph IWA-4170(a). Therefore, based on 10CFR50.55a(b)(2) and IWA-4170, later editions and addenda of ASME Section XI through the 1995 Edition and 1996 Addenda may be used for repair replacement activities without obtaining additional NRC approval. Accordingly, 10CFR50.55a(g)(4)(iv) does not apply to repair and replacement activities governed by IWA-4170.

ENCLOSURE 2

CNRO-2002-00022

**RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
PERTAINING TO REQUEST No. PWR-R&R-001, Rev. 0
(TAC Nos. MB4286, MB4288, and MB4289) DATED APRIL 18, 2002**

**RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
PERTAINING TO REQUEST No. PWR-R&R-001, Rev. 0
(TAC Nos. MB4286, MB4288, and MB4289) DATED APRIL 18, 2002**

1. American Society of Mechanical Engineers Boiler and Pressure Vessel Code (Code) 1992 Edition, IWA 4170(b) allows for repairs and installation of replacement items the use of later editions of Section III and states, "If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4200, IWA-4400, or IWA-4500 may be used."
 - a. Explain why a repair cannot be performed according to the criteria in Section III of the Code.

Response to Item 1a

See the response to Item 2, Part II in Enclosure 1.

- b. If an alternative to IWA-4XXX is determined necessary, explain why the repair should not be performed according to Section III requirements.

Response to Item 1b

See the response to Item 8 in Enclosure 1.

2. Assuming IWA-4530 applies, it has a limitation: "The repairs to a completed joint shall not exceed one-half the joint thickness. The surface of the completed repair shall not exceed 100 sq. in." From the descriptions of Figures 2 and 3 of the submittal dated March 29, 2002, the repairs could extend through-wall. Explain why Code limited repairs to one-half the joint thickness. What are the concerns with a through-wall temper bead repair?

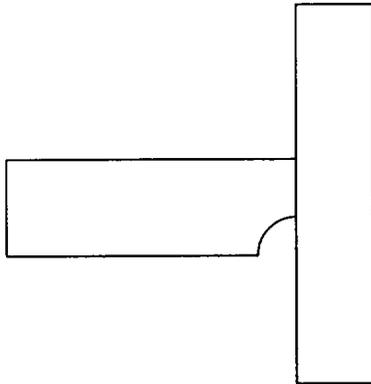
Response to Item 2

Entergy has deleted temper bead repairs of RPV penetration nozzle base materials from PWR-R&R-001 to clarify that it only applies to ambient temperature temper bead weld repairs of the J-weld. Entergy is not proposing a through-wall repair. Although the proposed weld repair may be a full throat or full depth repair of the partial penetration J-weld, it is not through-wall as explained below.

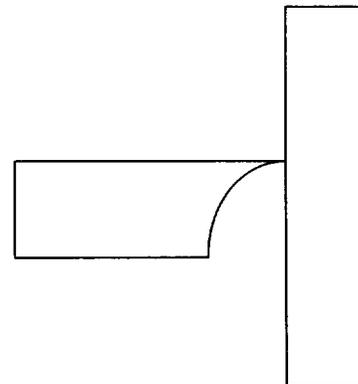
ASME Section IX, Welding and Brazing Qualifications, defines the terms "joint" and "joint penetration" as follows: [Identical or equivalent definitions are provided in American Welding Society's (AWS) standard ANSI/AWS A3.0-89, Standard Welding Terms and Definitions.]

- *Joint - The junction of members or the edges of members which are to be joined or have been joined.*
- *Joint Penetration – The minimum depth a groove weld extends from its face into a joint, exclusive of reinforcement.*

A "joint" is the junction of members to be welded irrespective of weld type (i.e. single bevel groove, double V-groove, J-groove, etc.) or depth of weld penetration (i.e. partial penetration or full penetration) in the joint. "Joint penetration" defines the depth of weld penetration in a joint. Full penetration welds penetrate the full length or depth of the adjoining members in a joint. Partial penetration welds only partially penetrate through the joint such that part of the joint remains unwelded. Examples of partial and full penetration J-welds in a "T-Joint" are shown below.



Partial Penetration J-Weld



Full Penetration J-Weld

The "joint" between the RPV head and each RPV penetration nozzle is best described as a T-Joint. The weld that attaches each RPV penetration nozzle to the RPV head is a partial penetration J-weld. Examples of partial penetration welds are shown in NB-4244(d)-1 of ASME Section III. The J-weld throat dimensions at ANO-1, ANO-2, and Waterford 3 are substantially less than one-half the joint thickness. Therefore, a full throat or full depth J-weld repair can be performed and not exceed the depth restriction of IWA-4330. See Response to Question 7 for additional information.

3. In Section IV of the submittal dated March 29, 2002, there is a statement that a significant reduction in radiation dose could be realized using an automated GTAW temper bead process over the temper bead process in 1992 Edition of the Code. Provide an estimate of the reduction in dosage for the repair.

Response to Item 3

Entergy estimates a dose reduction of at least 15 REM at both ANO-1 and Waterford 3 and at least 75 REM at ANO-2 if the proposed ambient temperature temper bead process is used. The higher dose reduction at ANO-2 is based on the fact that the insulation on the top of the RPV head cannot be removed. Therefore, the preheat/postweld soak equipment has to be installed under the RPV head where there are much higher dose rates.

4. Were microstructure evaluations performed on the as-welded material used for the demonstration? What proof is there that martensite is not present in the as-welded condition?

Response to Item 4

At Entergy's request, CONAM Inspection Group performed microstructural evaluations on the test coupon weld of the procedure qualification. Microstructural evaluations consisted of micro-hardness testing (Vickers) and metallography. Vickers micro-hardness testing was performed at three different locations across the weld, heat affected zone, and base material. Metallography was performed at 100X and 500X. According to the CONAM Laboratory Report #2333, "There were a few colonies of tempered martensite observed near the root of the weld. These seem to be associated with the slight banding present in the base material. There was no indication of untempered martensite. The remaining areas of the heat affected zone consist of a mixed microstructure of by-products of high temperature pearlite degeneration, bainite and a small amount of ferrite." Regarding the presence of carbides, the CONAM report stated: "There was no evidence of massive carbides or carbide networks." See revised relief request for micro-hardness test results and additional information.

5. In the second paragraph of page 9 of the submittal dated March 29, 2002, the statement is made that, "Any moisture on the surface of the component being welded will be vaporized ahead of the welding torch." The area of interest is the opening between the reactor pressure vessel (RPV) head, outside surface of the control element drive mechanism (CEDM), and above the J-groove weld. Hydrated boric acid crystals in this confined space may be a source of hydrogen and boron. The disassociated constituents from hydrated boric acid crystals would increase the susceptibility for cracks in steel. Describe the results and findings from the demonstration used to simulate the conditions that exist at the repair location. Discuss primary water stress corrosion cracking (PWSCC) tests performed on the weldment manufactured in the presence of hydrated boric acid crystals.

Response to Item 5

Entergy has not performed a demonstration simulating a temper bead repair of a J-weld with boric acid crystals trapped in the annulus. Entergy understands that the NRC staff has approved an ambient temperature temper bead repair of a J-weld for the North Anna Power Station.

6. The proposed non-destructive examination (NDE) of the weld surface and surrounding area is from a surface examination from inside the CEDM or the accessible surface of the J-groove weld. The surface examination of the opening between the RPV head, outside surface of the CEDM, and above the J-groove weld is inaccessible for a surface examination. If surface flaws were to occur as a result of the dissimilar metal weld (DMW) process, they would most likely occur at the inaccessible surface. Explain why cracks in the inaccessible surfaces DMW should not be a concern.

Response to Item 6

Entergy has deleted temper bead repairs of RPV penetration nozzle base materials from PWR-R&R-001. The relief request only addresses repairs to the J-weld. In addition, the request notes that flaws in the J-weld will be removed prior to performing any temper bead repairs of the J-weld. After completely excavating the defect, a liquid penetrant examination of the repair cavity will be performed to verify defect removal. During the repair operation, the repair weld shall be progressively examined in accordance with NB-5245 of ASME Section III. (The NB-5245 progressive liquid penetrant examination is the code-required examination for this weld according to ASME Section III.) After the completed weld has been at ambient temperature for at least 48 hours, the completed weld and a 5-inch band surrounding the weld shall be examined by the liquid penetrant method.

7. The proposed NDE of the repair to the J-groove weld is to use progressive liquid penetrant testing (PT). The progressive surface examination is applicable for partial penetration welds. For a full penetration weld in the J-groove, progressive PT may be appropriate. However, according to IWA-4533, the temper bead repair is surrounded by the weld material and that may extend into the RPV head material. Because the temper bead is surrounded by metal, it is not a partial penetration weld. Therefore, a temper bead repair should be volumetrically inspected. Explain why the repair cannot be volumetrically examined.

Response to Item 7

By definition, partial penetration welds are welds that do not penetrate the full depth of the joint. Conversely, full penetration welds penetrate the full depth of the joint. The 1989 Edition of ASME Section III allows the use of partial penetration welds to attach nozzles to vessels as follows:

- *According to NB-3337.3(a), "Partial penetration welds, as shown in Figs. NB-4244(d)-1 and NB-4244(d)-2, are allowed for nozzles..."*
- *According to NB-3352.4(d)(1), "Partial penetration welds used to connect nozzles as permitted in NB-3337.3 shall meet the fabrication requirements of NB-4244(d) and shall be capable of being examined in accordance with NB-5245."*
- *According to NB-4244(d), "Partial penetration welds in components and branch piping shall meet the weld design requirements of NB-3352.4(d). Nozzles shall be attached as shown in Figs. NB-4244(d)-1 and NB-4244(d)-2." Figures NB-4244(d)-1 and NB-4244(d)-2 provide details of approved partial penetration weld connections. These figures include dimensional requirements and clearly show that partial penetration welds are welds that do not penetrate the full depth of the weld joint.*

NB-5245 of ASME Section III specifies examination requirements for partial penetration welds as shown below. Based on NB-5245, partial penetration J-welds "shall be progressively examined" using the liquid penetrant method. The NB-5245 progressive examination requirement applies to the original partial penetration welds performed during initial fabrication and to repairs or replacements of these welds as ASME

Section XI repair/replacement activities. For clarification, if a partial penetration weld is completely excavated and rewelded, it remains a partial penetration weld; the design of the weld has not changed. Therefore, the examination requirements of NB-5245 still apply.

- *According to NB-5245, "Partial penetration welds, as permitted in NB-3352.4(d), and as shown in Figures NB-4244(d)-1 and NB-4244(d)-2, shall be examined progressively using either the magnetic particle or liquid penetrant method. The increments of examination shall be the lesser of one-half of the maximum weld dimension measured parallel to the centerline of the connection or ½-inch. The surface of the finished weld shall also be examined by either method."*

The IWA-4530 temper bead rules for dissimilar materials in the 1992 Edition of ASME Section XI were written with deference to butt weld repairs. This point is demonstrated by Figures IWA-4532.1-1 and IWA-4532.2-1. As a result, the examination requirements of IWA-4533 are also based upon repairs to butt welds (i.e. PT, RT, and if practical UT). Note that NB-5221 and NB-5222 of ASME Section III require that butt welds in vessels, piping, pumps, and valves be examined by the radiographic and liquid penetrant examination methods.

IWA-4533 does not address repairs to partial penetration welds such as J-welds used to attach nozzles to an RPV head. As explained above, the ASME Section III code required examination is a progressive surface examination performed in accordance with NB-5245. Furthermore, as explained in PWR-R&R-001, radiographic examination is impractical for weld repairs of RPV penetration nozzle J-welds; ultrasonic examination of the J-weld is also impractical because the technology, procedures, and techniques required to satisfactorily examine the J-weld do not exist. Therefore, the only examination that Entergy can perform on the partial penetration J-weld is a progressive liquid penetrant examination, which is also the code-required examination according to NB-5245.

8. The proposed NDE of the weld volume and surrounding area is a volumetric examination from inside the CEDM. The proposed examination is a single side DMW from inside the CEDM. Explain the reliability of the proposed ultrasonic testing (UT) to detect and characterize cracks in the RPV head performed from inside the CEDM. Discuss the detection of cracks located in the base material within the weld zone.

Response to Item 8

Entergy has deleted temper bead repairs of RPV penetration nozzle base materials from PWR-R&R-001.

9. Discuss the different demonstrations. Specifically, the orientation, kinds, types, number, and characteristics of the flaws and the flaw locations in the mock-up. Include a discussion of the flaws located in the weld zone of the CEDM and the steel head.
 - a. Discuss the cold isostatic pressure - electric discharge machined notches used in the mock-ups. How was the acoustic characteristic determined and how does it compare to PWSCC? What is the average tip radius and standard tip deviation for this process?
 - b. Discuss the representativeness of the flaws to PWSCC or welding cracks (shrinkage, hydrogen, or microstructure) in the heat affected zone of the steel head and in the CEDM.
 - c. Provide the technical justification, signal-to-noise ratios showing the presence of different type/size flaws, layout of flaw locations in the mock-ups, calibrations, and UT procedure. 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 9

Entergy has deleted temper bead repairs of RPV penetration nozzle base materials from PWR-R&R-001.

ENCLOSURE 3

CNRO-2002-00022

REQUEST No. PWR-R&R-001, Rev. 0

**ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNITS 1 and 2
WATERFORD STEAM ELECTRIC STATION, UNIT 3
REQUEST NO. PWR-R&R-001, Revision 0**

I. COMPONENT/EXAMINATION

Component/Number: 1R-1, 2R-1, and RC MRCT0001

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 References 9 , 10, and 12
 2. ASME Section III, 1965 Edition, Summer 1967 Addenda
 3. ASME Section III, 1968 Edition, Summer 1970 Addenda
 4. ASME Section III, Subsection NB, 1971 Edition, Summer 1971 Addenda
 5. ASME Section III, Subsection NB, 1971 Edition, Summer 1972 Addenda
 6. ASME Section III, Subsection NB, 1989 Edition
 7. ASME Section XI Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique"
 8. EPRI Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications"
 9. CEP-ISI-001, "Waterford 3 Steam Electric Station Inservice Inspection Plan"
 10. CEP-ISI-004, "Arkansas Nuclear One Unit 2 Inservice Inspection Plan"
 11. Entergy Letter No. 1CAN090102, "30 Day Response to NRC Bulletin 2001-01 for ANO-1; Circumferential Cracking of VHP Nozzles," dated September 4, 2001
 12. CEP-ISI-002, "Arkansas Nuclear One Unit 1 Inservice Inspection Plan"
 13. Entergy Letter No. 2CAN090102, "30 Day Response to NRC Bulletin 2001-01 for ANO-2; Circumferential Cracking of VHP Nozzles," dated September 4, 2001

14. Entergy Letter No. W3F1-2001-0081, "30 Day Response to NRC Bulletin 2001-01 for Waterford 3; Circumferential Cracking of VHP Nozzles," dated September 4, 2001
15. CONAM Inspection Laboratory Report #2333, dated July 23, 2002

Unit / Inspection Interval:

Arkansas Nuclear One Unit 1 (ANO-1) / Third (3rd) 10-Year interval

Arkansas Nuclear One Unit 2 (ANO-2) / Third (3rd) 10-Year interval

Waterford 3 Steam Electric Station (Waterford 3) / Second (2nd) 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. If repair welding cannot be performed in accordance with these requirements, the applicable requirements of IWA-4200, IWA-4400, or IWA-4500 may be used."

IWA-4500 of ASME Section XI establishes alternative repair welding methods for performing temper bead welding. According to IWA-4500(a), "Repairs to base materials and welds identified in IWA-4510, IWA-4520, and IWA-4530 may be made by welding without the specified postweld heat treatment requirements of the Construction Code or Section III, provided the requirements of IWA-4500(a) through (e) and IWA-4510, IWA-4520, or IWA-4530, as applicable, are met."

IWA-4530 applies to dissimilar materials such as welds that join P-Number 43 nickel alloy to P-Number 3 low alloy steels. According to IWA-4530, "Repairs to welds that join P-No. 8 or P-No. 43 material to P-Nos. 1, 3, 12A, 12B, and 12C material may be made without the specified postweld heat treatment provided the requirements of IWA-4530 through IWA-4533 are met. Repairs made to this paragraph are limited to those along the fusion line of a nonferritic weld to ferritic base material where 1/8-inch or less of nonferritic weld deposit exists above the original fusion line after defect removal."

Temper bead repairs of RPV head penetration nozzle J-welds are performed in accordance with IWA-4500 and IWA-4530 whenever the repair cavity is within 1/8-inch of the ferritic base materials of the RPV head. When the Gas Tungsten Arc Welding (GTAW) process is used in accordance with IWA-4500 and IWA-4530, then temper bead welding is performed as follows:

- Only the automatic or machine GTAW process using cold wire feed can be used. Manual GTAW cannot be used.

- A minimum preheat temperature of 300°F is established and maintained throughout the welding process. Interpass temperature cannot exceed 450°F.
- The weld cavity is buttered with at least six (6) layers of weld metal.
- Heat input of the initial six layers is controlled to within +/-10% of that used for the first six layers during procedure qualification testing.
- After the first six weld layers, repair welding is completed with a heat input that is equal to or less than that used in the procedure qualification for weld layers seven and beyond.
- Upon completion of welding, a postweld soak or hydrogen bake-out at 450°F - 550°F for a minimum of 4 hours is required.
- Preheat, interpass, and postweld soak temperatures are monitored using thermocouples and recording instruments.
- The repair weld and preheated band are examined in accordance with IWA-4533 after the completed weld has been at ambient temperature for 48 hours.

III. PROPOSED ALTERNATIVE

A. Background

RPV head penetration nozzles at ANO-2 and Waterford 3 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 3 time-at-temperature condition. ANO-1 has already experienced cracking. Susceptibility rankings for ANO-1, ANO-2, and Waterford 3 have been reported to the NRC in response to NRC Bulletin 2001-01 (References 11, 13, and 14).

Should repair welding of RPV head penetration nozzle J-welds encroach (within 1/8-inch) on the ferritic base material of the RPV head, temper bead weld repairs would be required. See the following figures for additional details.

- Figure 1: Typical RPV Head Penetration Nozzle
- Figure 2: Example Repair of an RPV Head Penetration Nozzle J-Weld

B. Proposed Alternative

Pursuant to 10CFR50.55a(a)(3)(i), Entergy proposes alternatives to the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Section XI. Specifically, Entergy proposes to perform ambient temperature temper bead welding in accordance with Attachment 1, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique."

Entergy has reviewed the proposed ambient temperature temper bead welding techniques of Attachment 1 against the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530. This review was performed to identify differences between Attachment 1 and IWA-4500 and IWA-4530. Based upon this review, Entergy proposes alternatives to the following ASME Section XI requirements of IWA-4500 and IWA-4530:

1. **IWA-4500(a)** specifies that repairs to base materials and welds identified in IWA-4530 may be performed without the specified postweld heat treatment of the construction code or ASME Section III provided the requirements of IWA-4500 and IWA-4530 are met. IWA-4530 includes temper bead requirements applicable to the Shielded Metal Arc Welding (SMAW) and the machine or automatic GTAW processes. As an alternative, Entergy proposes to perform temper bead weld repairs using the ambient temperature temper bead technique described in Attachment 1. Only the machine or automatic GTAW process can be used when performing ambient temperature temper bead welding in accordance with Attachment 1.
2. **IWA-4500(d)(2)** specifies that if repair welding is to be performed where physical obstructions impair the welder's ability to perform, the welder shall also demonstrate the ability to deposit sound weld metal in the positions, using the same parameters and simulated physical obstructions as are involved in the repair. This limited accessibility demonstration applies when manual temper bead welding is performed using the Shielded Metal Arc Welding (SMAW) process. It does not apply to "welding operators" who perform machine or automatic GTAW welding from a remote location. (This distinction is clearly made in IWA-4500 and IWA-4530.) Because the proposed ambient temperature temper bead technique described in Attachment 1 utilizes a machine GTAW welding process, limited access demonstrations of "welding operators" are not required. Therefore, the requirement of IWA-4500(d)(2) does not apply.
3. **IWA-4500(e)(2)** specifies that the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 300°F for the GTAW process during welding; maximum interpass temperature shall be 450°F. As an alternative, Entergy proposes that the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 50°F for the GTAW process during welding; maximum interpass temperature shall be 150°F for the 1/8-inch butter thickness (first three weld layers as a minimum) and 350°F for the balance of welding.
4. **IWA-4500(e)(2)** specifies that thermocouples and recording instruments shall be used to monitor process temperatures. As an alternative, Entergy proposes to monitor preheat and interpass temperatures using an infrared thermometer.

5. **IWA-4500(e)(2)** specifies that thermocouple attachment and removal shall be performed in accordance with ASME Section III. Because Entergy will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the thermocouple attachment and removal requirements of IWA-4500(e)(2) do not apply.
6. **IWA-4532.1** establishes procedure technique requirements that apply when using the SMAW process. Because the proposed ambient temperature temper bead technique of Attachment 1 utilizes the machine or automatic GTAW welding process, the SMAW temper bead technique requirements of paragraph IWA-4532.1 do not apply.
7. **IWA-4532.2** establishes procedure technique requirements that apply when using the GTAW process but do not address joint design qualification of the repair cavity. As an alternative, Entergy proposes to qualify the joint design of the proposed repair cavity by requiring that the root width and included angle of the repair cavity in the test assembly be no greater than the minimum specified for the repair.
8. **IWA-4532.2(c)** specifies that the repair cavity shall be buttered with six layers of weld metal in which the heat input of each layer is controlled to within +/-10% of that used in the procedure qualification test, and heat input control for subsequent layers shall be deposited with a heat input equal to or less than that used for layers beyond the sixth in the procedure qualification. As an alternative, Entergy proposes to butter the weld area with a minimum of three layers of weld metal to obtain a minimum butter thickness of 1/8-inch. The heat input of each weld layer in the 1/8-inch thick buttered section shall be controlled to within +/-10% of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick buttered section (first three weld layers) in the procedure qualification.
9. **IWA-4532.2(c)** specifies that the completed weld shall have at least one layer of weld reinforcement deposited and then this reinforcement shall be removed by mechanical means. As an alternative, Entergy's proposed ambient temperature temper bead technique does not include a reinforcement layer.
10. **IWA-4532.2(d)** specifies that, after at least 3/16-inch of weld metal has been deposited, the weld area shall be maintained at a temperature of 450°F - 550°F for a minimum of four (4) hours (for P-No. 3 materials). As an alternative, Entergy's proposed ambient temperature temper bead technique does not include a postweld soak.
11. **IWA-4532.2(e)** specifies that after depositing at least 3/16-inch of weld metal and performing a postweld soak at 450°F - 550°F, the balance of welding may be performed at an interpass temperature of 350°F. As an alternative, Entergy's proposes that an interpass temperature of 350°F may be used after depositing at least 1/8-inch of weld metal without a postweld soak.
12. **IWA-4533** specifies the following examinations shall be performed after the completed repair weld has been at ambient temperature for at least 48 hours:

(a) the repair weld and preheated band shall be examined by the liquid penetrant method; (b) the repaired region shall be volumetrically examined by the radiographic method, and if practical, by the ultrasonic method. Entergy will perform the liquid penetrant examination of the completed repair weld and preheated band as required by IWA-4533. As an alternative to the volumetric examination of IWA-4533, Entergy proposes the following examinations for repair welds in RPV penetration nozzle J-welds.

- Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. The liquid penetrant examinations will be performed in accordance with NB-5000. Acceptance criteria shall be in accordance with NB-5350.

This request for alternative is specific to localized weld repair of RPV head penetration nozzle J-welds where 1/8-inch or less of Inconel weld metal exists between the J-weld repair cavity and the ferritic base material of the RPV head. See Figures 1 and 2. Flaws in the J-weld will be removed prior to performing any temper bead repairs in accordance with this relief request.

IV. BASIS FOR PROPOSED ALTERNATIVE

IWA-4500 and IWA-4530 of ASME Section XI establish requirements for performing temper bead welding of "dissimilar materials". According to IWA-4530, either the automatic or machine GTAW process or SMAW process may be used. When using the machine GTAW process, a minimum preheat temperature of 300°F must be established and maintained throughout the welding process while the interpass temperature is limited to 450°F. Upon completion of welding, a postweld soak is performed at 450°F - 550°F for a minimum of 4 hours.

The IWA-4500 and IWA-4530 temper bead welding process is a time and dose intensive process. Resistant heating blankets are attached to the RPV head; typically a capacitor discharge stud welding process is used. Thermocouples must also be attached to the RPV head using a capacitor discharge welding process to monitor preheat, interpass, and postweld soak temperatures. Prior to heat-up, thermal insulation is also installed. Upon completion of repair welding (including the postweld soak), the insulation, heating blankets, studs, and thermocouples must be removed from the RPV head. Thermocouples and stud welds are removed by grinding. Ground removal areas are subsequently examined by the liquid penetrant or magnetic particle method. A significant reduction in dose could be realized by utilizing an ambient temperature temper bead process. Because the ASME Code does not presently include rules for ambient temperature temper bead welding, Entergy proposes the alternative described in Section III.B.

Suitability of Proposed Ambient Temperature Temper Bead Technique

A. Evaluation of the Ambient Temperature Temper Bead Technique

Research by the Electric Power Research Institute (EPRI) and other organizations on the use of an ambient temperature temper bead operation using the machine GTAW process is documented in EPRI Report GC-111050. According to the EPRI report, repair welds performed with an ambient temperature temper bead procedure utilizing the machine GTAW welding process exhibit mechanical properties equivalent or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

The effects of the ambient temperature temper bead welding process of Attachment 1 on mechanical properties of repair welds, hydrogen cracking, and restraint cracking are addressed below.

1. MECHANICAL PROPERTIES

The principal reasons to preheat a component prior to repair welding is to minimize the potential for cold cracking. The two cold cracking mechanisms are hydrogen cracking and restraint cracking. Both of these mechanisms occur at ambient temperature. Preheating slows down the cooling rate resulting in a ductile, less brittle microstructure thereby lowering susceptibility to cold cracking. Preheat also increases the diffusion rate of monatomic hydrogen that may have been trapped in the weld during solidification. As an alternative to preheat, the ambient temperature temper bead welding process utilizes the tempering action of the welding procedure to produce tough and ductile microstructures. Because precision bead placement and heat input control is characteristic of the machine GTAW process, effective tempering of weld heat affected zones is possible without the application of preheat. According to Section 2-1 of EPRI Report GC-111050, "the temper bead process is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat affected zone such that the desired degree of carbide precipitation (tempering) is achieved. The resulting microstructure is very tough and ductile."

The IWA-4530 temper bead process also includes a postweld soak requirement. Performed at 450°F to 550°F for 4 hours (P-Number 3 base materials), this postweld soak assists diffusion of any remaining hydrogen from the repair weld. As such, the postweld soak is a hydrogen bake-out and not a postweld heat treatment as defined by the ASME Code. At 450°F to 550°F, the postweld soak does not stress relieve, temper, or alter the mechanical properties of the weldment in any manner.

Section 2.1 of Attachment 1 establishes detailed welding procedure qualification requirements. Simulating base materials, filler metals, restraint, impact properties, and procedure variables, the qualification requirements of Section 2.1 provide assurance that the mechanical properties of repair welds will be equivalent or superior to those of the surrounding base material. It should also be noted that the qualification requirements of Section 2.1 of

Attachment 1 are identical to those in IWA-4530. Ambient temperature temper bead WPS 3-43/52-TB MC-GTAW-N638 was qualified in accordance with Attachment 1. Based upon the procedure qualification test results, the impact properties of the base material heat affected zone were superior to those of the unaffected base material. The mechanical testing results for the procedure qualification are summarized in Section IV.C.

2. HYDROGEN CRACKING

Hydrogen cracking is a form of cold cracking. It is produced by the action of internal tensile stresses acting on low toughness heat affected zones. The internal stresses are produced from localized build-ups of monatomic hydrogen. Monatomic hydrogen forms when moisture or hydrocarbons interact with the welding arc and molten weld pool. The monatomic hydrogen can be entrapped during weld solidification and tends to migrate to transformation boundaries or other microstructure defect locations. As concentrations build, the monatomic hydrogen will recombine to form molecular hydrogen – thus generating localized internal stresses at these internal defect locations. If these stresses exceed the fracture toughness of the material, hydrogen induced cracking will occur. This form of cracking requires the presence of hydrogen and low toughness materials. It is manifested by intergranular cracking of susceptible materials and normally occurs within 48 hours of welding.

IWA-4500 establishes elevated preheat and postweld soak requirements. The elevated preheat temperature of 300°F increases the diffusion rate of hydrogen from the weld. The postweld soak at 450°F was also established to bake-out or facilitate diffusion of any remaining hydrogen from the weldment. However, while hydrogen cracking is a concern for SMAW which uses flux covered electrodes, the potential for hydrogen cracking is significantly reduced when using the machine GTAW welding.

The machine GTAW welding process is inherently free of hydrogen. Unlike the SMAW process, GTAW welding filler metals do not rely on flux coverings that are susceptible to moisture absorption from the environment. Conversely, the GTAW process utilizes dry inert shielding gases that cover the molten weld pool from oxidizing atmospheres. Any moisture on the surface of the component being welded will be vaporized ahead of the welding torch. The vapor is prevented from being mixed with the molten weld pool by the inert shielding gas that blows the vapor away before it can be mixed. Furthermore, modern filler metal manufacturers produce wires having very low residual hydrogen. This is important because filler metals and base materials are the most realistic sources of hydrogen for automatic or machine GTAW temper bead welding.

As explained above, the potential for hydrogen induced cracking is greatly reduced by using machine GTAW process. However, should it occur, cracks would be detected by the final nondestructive examinations (NDE) performed after the completed repair weld has been at ambient temperature for at least 48 hours as required in Section 4.0 of Attachment 1. Regarding this issue, EPRI Report GC-111050, Section 6.0 concluded the following:

“No preheat temperature or postweld bake above ambient temperature is required to achieve sound machine GTAW temper bead repairs that have high toughness and ductility. This conclusion is based on the fact that the GTAW process is an inherently low hydrogen process regardless of the welding environment. Insufficient hydrogen is available to be entrapped in solidifying weld material to support hydrogen delayed cracking. Therefore, no preheat nor postweld bake steps are necessary to remove hydrogen because the hydrogen is not present with the machine GTAW process.”

3. COLD RESTRAINT CRACKING

Cold cracking generally occurs during cooling at temperatures approaching ambient temperature. As stresses build under a high degree of restraint, cracking may occur at defect locations. Brittle microstructures with low ductility are subject to cold restraint cracking. However, the ambient temperature temper bead process is designed to provide a sufficient heat inventory so as to produce the desired tempering for high toughness. Because the machine GTAW temper bead process provides precision bead placement and control of heat, the toughness and ductility of the heat affected zone will typically be superior to the base material. Therefore, the resulting structure will be appropriately tempered to exhibit toughness sufficient to resist cold cracking. Additionally, even if cold cracking were to occur, it would be detected by the final NDE which is performed after the completed repair weld has been at ambient temperature for at least 48 hours as required in Section 4.0 of Attachment 1.

In conclusion, no elevated preheat or postweld soak above ambient temperature is required to achieve sound and tough repair welds when performing ambient temperature temper bead welding using the machine GTAW process. This conclusion is based upon strong evidence that hydrogen cracking will not occur with the GTAW process. In addition, automatic or machine temper bead welding procedures without preheat will produce satisfactory toughness and ductility properties both in the weld and weld heat affected zones. The results of previous industry qualifications and repairs further support this conclusion. The use of an ambient temperature temper bead welding procedure will improve the feasibility of performing localized weld repairs with a significant reduction in radiological exposure. EPRI Report GC-111050, Section 6.0 concluded the following:

“Repair of RPV components utilizing machine GTAW temper bead welding at ambient temperature produces mechanical properties that are commonly superior to those of the service-exposed substrate. The risk of hydrogen delayed cracking is minimal using the GTAW process. Cold stress cracking is resisted by the excellent toughness and ductility developed in the weld HAZ (heat affected zone). Process design and geometry largely control restraint considerations, and these factors are demonstrated during weld procedure qualification.”

B. Evaluation of Proposed Alternatives to ASME Section XI, IWA-4500 and IWA-4530

1. According to **IWA-4500(a)**, repairs may be performed to dissimilar base materials and welds without the specified postweld heat treatment of ASME

Section III provided the requirements of IWA-4500 and IWA-4530 are met. The temper bead rules of IWA-4500 and IWA-4530 apply to dissimilar materials such as P-No. 43 to P-No. 3 base materials welded with F-No. 43 filler metals. When using the GTAW-machine process, the IWA-4500 and IWA-4530 temper bead process is based fundamentally on an elevated preheat temperature of 300°F, a maximum interpass temperature of 450°F, and a postweld soak of 450°F - 550°F. The proposed alternative of Attachment 1 also establishes requirements to perform temper bead welding on dissimilar material welds that join P-No. 43 to P-No. 3 base materials using F-No. 43 filler metals. However, the temper bead process of Attachment 1 is an ambient temperature technique which only utilizes the GTAW-machine or GTAW-automatic process. The suitability of the proposed ambient temperature temper bead technique is evaluated in this section. The results of this evaluation demonstrate that the proposed ambient temperature temper bead technique provides an acceptable level of quality and safety.

2. According to **IWA-4500(e)(2)**, the weld area plus a band around the repair 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 300°F for the GTAW process during welding while the maximum interpass temperature is limited to 450°F. The ambient temperature temper bead technique of Attachment 1 also establishes a preheat band of at least 1½ times the component thickness or 5 inches, whichever is less. However, the ambient temperature temper bead technique requires a minimum preheat temperature of 50°F, a maximum interpass temperature of 150°F for the first three layers, and a maximum interpass temperature of 350°F for the balance of welding. The suitability of an ambient temperature temper bead technique with reduced preheat and interpass temperatures is addressed in Section IV.A.
3. According to **IWA-4500(e)(2)**, thermocouples and recording instruments shall be used to monitor process temperatures. As an alternative to IWA-4500(e)(2), Entergy proposes to monitor preheat and interpass temperatures using an infrared thermometer. Infrared thermometers are hand-held devices that can be used to monitor process temperature from a remote location. To determine the preheat and interpass temperatures during the welding operation, the infrared thermometer is pointed at a target location adjacent to the repair weld. The target location is identified by a circle consisting of eight laser spots. A single laser spot in the center of the circle identifies the center of the measurement area. As the distance (D) from the object being measured increases, the diameter of the target location or "spot size" (S) also increases. The optics of the infrared thermometer sense emitted, reflected, and transmitted energy from the target location that is collected and focused onto a detector. The infrared thermometer's electronics translate the information into a temperature reading that is displayed on the unit. The infrared thermometer measures the maximum, minimum, differential, and average temperatures across the target location. This data can be stored and recalled until a new measurement is taken. Entergy plans to use an infrared thermometer such as the Raytek Raynger ST80 (or equivalent). The Raytek Raynger ST80 infrared thermometer measures temperatures from -25°F to 1400°F over the target location with the following accuracy: +/-3°F over the

0°F - 73°F temperature range and +/-1% of reading or 2°F, whichever is greater, above 73°F. Display resolution is 0.1°F. The distance (D) to "spot size" (S) is 50:1 for the Raytek Raynger ST80 infrared thermometer. Since the "distance" (D) to the target location on the RPV penetration nozzle or J-weld is estimated to range from 3 feet to 6 feet, the "spot size" (S) will also range from 0.72 inch to 2.22 inches. The infrared thermometer will be appropriately calibrated prior to use.

4. **IWA-4532.2** establishes procedure technique requirements but do not address joint design access qualification of the repair cavity. As an alternative to IWA-4532.2, Entergy proposes to qualify the root width and included angle of the proposed repair cavity. Paragraph 2.1(c) of Attachment 1 requires that the root width and included angle of the repair cavity in the test assembly be no greater than the minimum specified for the repair. This requirement ensures that the welding procedure is only used in repair cavity configurations where it has demonstrated capability (i.e. sufficient access to deposit root passes, tie-in to the beveled or tapered walls of the repair cavity, provide appropriate tempering, and ensure complete weld fusion).
5. According to **IWA-4532.2(c)**, the repair cavity shall be buttered with six layers of weld metal in which the heat input of each layer is controlled to within +/-10% of that used in the procedure qualification test, and heat input control for subsequent layers shall be deposited with a heat input equal to or less than that used for layers beyond the sixth in the procedure qualification. As an alternative to IWA-4532.2, Entergy proposes to butter the repair cavity or weld area with at least three layers of weld metal to obtain a minimum butter thickness of 1/8-inch. The heat input of each layer in the 1/8-inch thick buttered section shall be controlled to within +/-10% of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick buttered section (first three weld layers) in the procedure qualification. When using the ambient temperature temper bead technique of Attachment 1, the machine GTAW process is used. Machine GTAW is a low heat input process that produces consistent small volume heat affected zones. Subsequent GTAW weld layers introduce heat into the heat affected zone produced by the initial weld layer. The heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop a correct degree of tempering in the underlying heat affected zone. When welding dissimilar materials with nonferritic weld metal, the area requiring tempering is limited to the weld heat affected zone of the ferritic base material along the ferritic fusion line.

After buttering the ferritic base material with at least 1/8-inch of weld metal (first 3 weld layers), subsequent weld layers should not provide any additional tempering to the weld heat affected zone in the ferritic base material. Therefore, less restrictive heat input controls are adequate after depositing the 1/8-inch thick buttered section. It should also be noted that IWA-4530 does not require temper bead welding except "where 1/8-inch or less of nonferritic weld deposit exists above the original fusion line after defect removal". The proposed heat input techniques of Attachment 1 were utilized in the qualification of Welding Procedure Specification (WPS) 3-43/52-TB MC-

GTAW-N638. Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in weld heat affected zone were superior to those of the unaffected base material. Therefore, the proposed heat input controls of Attachment 1 provide an appropriate level of tempering. Test results of the WPS qualification are provided in Section IV.C.

6. According to **IWA-4532.2(c)**, at least one layer of weld reinforcement shall be deposited on the completed weld and with this reinforcement being subsequently removed by mechanical means. In the proposed alternative of Attachment 1, the deposition and removal of a reinforcement layer is not required. A reinforcement layer is required when a weld repair is performed to a ferritic base material or ferritic weld using a ferritic weld metal. On ferritic materials, the weld reinforcement layer is deposited to temper the last layer of untempered weld metal of the completed repair weld. Because the weld reinforcement layer is untempered (and unnecessary), it is removed. However, when repairs are performed to dissimilar materials using nonferritic weld metal, a weld reinforcement layer is not required because nonferritic weld metal does not require tempering. When performing a dissimilar material weld with a nonferritic filler metal, the only location requiring tempering is the weld heat affected zone in the ferritic base material along the weld fusion line. However, the three weld layers of the 1/8-inch thick butter section are designed to provide the required tempering to the weld heat affected zone in the ferritic base material. Therefore, a weld reinforcement layer is not required. While Entergy recognizes that IWA-4532.2(c) does require the deposition and removal of a reinforcement layer on repair welds in dissimilar materials, Entergy does not believe that this reinforcement layer is necessary. This position is supported by the fact that ASME Code Case N-638 only requires the deposition and removal of a reinforcement layer when performing repair welds on similar (ferritic) materials. Repair welds on dissimilar materials are exempt from this requirement.
7. According to **IWA-4532.2(d)**, the weld area shall be maintained at a temperature of 450°F - 550°F for a minimum of 4 hours (for P-No. 3 materials) after at least 3/16-inch of weld metal has been deposited. In the proposed alternative of Attachment 1, a postweld soak is not required. The suitability of an ambient temperature temper bead technique without a postweld soak is addressed in Section IV.A.
8. According to **IWA-4532.2(e)**, after depositing at least 3/16-inch of weld metal and performing a postweld soak at 450°F-550°F, the balance of welding may be performed at an interpass temperature of 350°F. As an alternative, Entergy's proposes that an interpass temperature of 350°F may be used after depositing at least 1/8 inch of weld metal without a postweld soak. The proposed ambient temperature temper bead process of Attachment 1 is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat affected zone such that the desired degree of carbide precipitation (tempering) is achieved. The resulting microstructure is very tough and ductile. This point is validated by the qualification of WPS 3-43/52-TB MC-GTAW-N638. Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in weld heat affected zone were superior to those of the unaffected base

material. Test results of the WPS qualification are provided in Section IV.C. The suitability of an ambient temperature temper bead technique without a postweld soak is addressed in Section IV.A.

9. **IWA-4533** specifies that the repair weld shall be volumetrically examined by the radiographic method, and if practical, by the ultrasonic method after the completed repair weld has been at ambient temperature for at least 48 hours. As an alternative to the volumetric examinations of IWA-4533, Entergy proposes the examinations of repair welds in RPV penetration nozzle J-welds described below. The suitability of the alternative examinations is addressed in Section IV.D.

- Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. The liquid penetrant examinations will be performed in accordance with NB-5000. Acceptance criteria shall be in accordance with NB-5350.

C. Mechanical Properties of WPS 3-43/52-TB MC-GTAW-N638

WPS 3-43/52-TB MC-GTAW-N638 was qualified in accordance with Attachment 1. The welding procedure qualification test assembly was 3 inches thick and consisted of SA-533, Grade B, Class 1 (P-No. 3, Group 3) and SB-166, N06690 (P-No. 43) base materials. Prior to welding, the SA-533, Grade B, Class 1 portion of the test assembly was heat treated for 40 hours at 1,200°F. The repair cavity in the test assembly was 1.5 inches deep. The test assembly cavity was welded in the 3G (vertical) position using ERNiCrF3-7 (F-No. 43) filler metal. Results of the welding procedure qualification were documented on procedure qualification record PQR 707. Results of mechanical testing – tensile testing, bend testing, Charpy V-notch testing, and drop weight testing – are summarized below. WPS 3-43/52-TB MC-GTAW-N638 will be used to perform the repair welding activities described in Section III.B.

- Tensile test specimens exhibited a tensile strength that exceeded 80,000 psi and were acceptable per ASME Section IX. The bend testing was also acceptable. Test results are as follows:

Tensile Test Results

Specimen No.	Tensile Specimen	Actual Tensile Strength	Failure
Test 1-1	0.505" Turned Specimen	86,600 psi	Ductile/Base
Test 1-2	0.505" Turned Specimen	84,500 psi	Ductile/Base
Test 2-3	0.505" Turned Specimen	82,400 psi	Fusion Line
Test 2-4	0.505" Turned Specimen	86,600 psi	Ductile/Weld Metal

Bend Test Results

Specimen Type and Figure No.	Result
Side Bend 1 QW-462.2	Acceptable
Side Bend 2 QW-462.2	Acceptable
Side Bend 3 QW-462.2	Acceptable
Side Bend 4 QW-462.2	Acceptable

- Drop weight and Charpy V-notch testing of the SA-533, Grade B, Class 1 “unaffected” base material was performed. Based upon drop weight testing of the SA-533, Grade B, Class 1 “unaffected” base material, a nil ductility transition temperature (T_{NDT}) of -50°F was established. Charpy V-notch testing was also performed at $+10^{\circ}\text{F}$. All three Charpy V-notch specimens exhibited at least 35 mils and 50 ft-lbs. Based upon the above testing, an RT_{NDT} of -50°F was established for the SA-533, Grade B, Class 1 base material. Test results are as follows:

Drop Weight Test: Unaffected Base Material

Specimen ID	Specimen Type	Test Temperature	Drop Weight Break	T_{NDT}
DW1	P-3	-40°F	No	-50°F
DW2	P-3	-40°F	No	-50°F

Charpy V-Notch Tests: Unaffected Base Material

Specimen ID	Test Temperature	Absorbed Energy (ft-lbs)	Lateral Expansion(mils)	% Shear Fracture
1	$+10^{\circ}\text{F}$	59.0	50.0	60.0
2	$+10^{\circ}\text{F}$	51.0	43.0	50.0
3	$+10^{\circ}\text{F}$	50.0	45.0	50.0
Average	$+10^{\circ}\text{F}$	53.3	46.0	53.3

- Charpy V-notch testing of the SA-533, Grade B, Class 1 heat affected zone was also performed at $+10^{\circ}\text{F}$. The absorbed energy, lateral expansion, and percent shear fracture of the heat affected zone test specimens were compared to the test values of the unaffected base material specimens. The average values of the three heat affected zone specimens were greater than those of the unaffected base material specimens. Based upon these results, it is clear that the proposed ambient temperature temper bead process improved the heat affected zone properties. Test results are as follows:

Charpy V-Notch Tests: Heat Affected Zone

Specimen ID	Test Temperature	Absorbed Energy (ft-lbs)	Lateral Expansion(mils)	% Shear Fracture
1	$+10^{\circ}\text{F}$	85.0	65.0	90.0
2	$+10^{\circ}\text{F}$	136.0	64.0	75.0
3	$+10^{\circ}\text{F}$	124.0	49.0	30.0
Average	$+10^{\circ}\text{F}$	115.0	59.3.0	65.0

Supplemental microstructural evaluations were also performed on the test coupon weld of the procedure qualification. Microstructural evaluations consisted of micro-hardness testing (Vickers) and metallography. Vickers micro-hardness testing was performed at three different locations:

- 0.125 inch below the surface of the weld,

2. 0.625 inch below the surface of the weld, and
3. 0.125 inch above the root of the weld.

Micro-hardness test values are provided in the table below.

Metallography was performed at 100X and 500X magnifications. According to CONAM Laboratory Report #2333, "There were a few colonies of tempered martensite observed near the root of the weld. These seem to be associated with the slight banding present in the base material. There was no indication of untempered martensite. The remaining areas of the heat affected zone consist of a mixed microstructure of by-products of high temperature pearlite degeneration, bainite and a small amount of ferrite." Regarding the presence of carbides, the CONAM report stated, "There was no evidence of massive carbides or carbide networks."

Vickers Micro-Hardness Tests Results

Weld Zone Location	0.125" From Surface		0.625" From Surface		0.125" Above Weld Root	
	Filar	Vickers	Filar	Vickers	Filar	Vickers
Unaffected Base Material	182	224	184	219	182	224
	182	224	185	217	176	240
	183	222	186	214	174	245
	182	224	186	214	181	226
	184	219	182	224	178	234
	184	219	187	212	173	248
HAZ Grain Coarsened Region	167	266	162	283	150	330
	165	273	164	276	144	358
	165	273	169	260	144	358
HAZ Adjacent to Fusion Line	163	279	161	287	149	334
	161	287	161	287	147	343
Weld Metal	159	293	164	276	147	343
	183	222	187	212	190	205
	189	208	192	201	189	208
	184	219	185	217	186	214
	184	219	185	217	182	224
	189	208	183	222	182	224
	193	199	184	219	179	232

D. Suitability of Alternative Nondestructive Examinations (NDE)

IWA-4533 specifies that the repaired region shall be examined by the radiographic method, and if practical, by the ultrasonic method. The NDE requirements of IWA-4533 were established based upon a temper bead weld repair to butt welds. Figures IWA-4532.1-1 and IWA-4532.2-1 clearly indicate this. While the requirement to perform a radiographic examination, and if practical, an ultrasonic examination of a butt weld between a nozzle and pipe is appropriate, these examinations are not appropriate for weld repairs of RPV head penetration nozzle J-welds. See Figures 1 and 2.

Impracticality of Volumetric Examinations

Radiographic examination of weld repairs of RPV head penetration nozzle J-welds is not practical. Meaningful radiographic examination cannot be performed due to the weld configuration and access limitations. The weld configuration and geometry of the penetration in the head provide an obstruction for the radiography and interpretation would be very difficult. Ultrasonic examination of the J-weld would also be impractical.

Suitability of Proposed Alternative

As an alternative to radiographic and ultrasonic examinations, Entergy proposes to perform a progressive liquid penetrant of the J-weld repair weld in accordance with NB-5245 of ASME Section III. It should be noted that ASME Section III does not require volumetric examination of J-welds. According to NB-3352.4(d)(1), "partial penetration welds used to connect nozzles as permitted in NB-3337.3 shall meet the fabrication requirements of NB-4244(d) and shall be capable of being examined in accordance with NB-5245." NB-4244(d) establishes fabrication details for nozzles welded with partial penetration welds as shown in Figures NB-4244(d)-1 and NB-4244(d)-2.

According to NB-5245, "Partial penetration welds, as permitted in NB-3352.4(d), and as shown in Figures NB-4244(d)-1 and NB-4244(d)-2, shall be examined progressively using either the magnetic particle or liquid penetrant method. The increments of examination shall be the lesser of one-half of the maximum weld dimension measured parallel to the centerline of the connection or 1/2-inch. The surface of the finished weld shall also be examined by either method."

The partial penetration J-welds of the RPV head penetration nozzles were designed and fabricated in accordance with NB-3352.4(d) and NB-4244(d). Therefore, according to NB-3352.4(d), the code required examination for these partial penetration J-welds is a progressive liquid penetrant examination performed in accordance with NB-5245. A volumetric examination is not required.

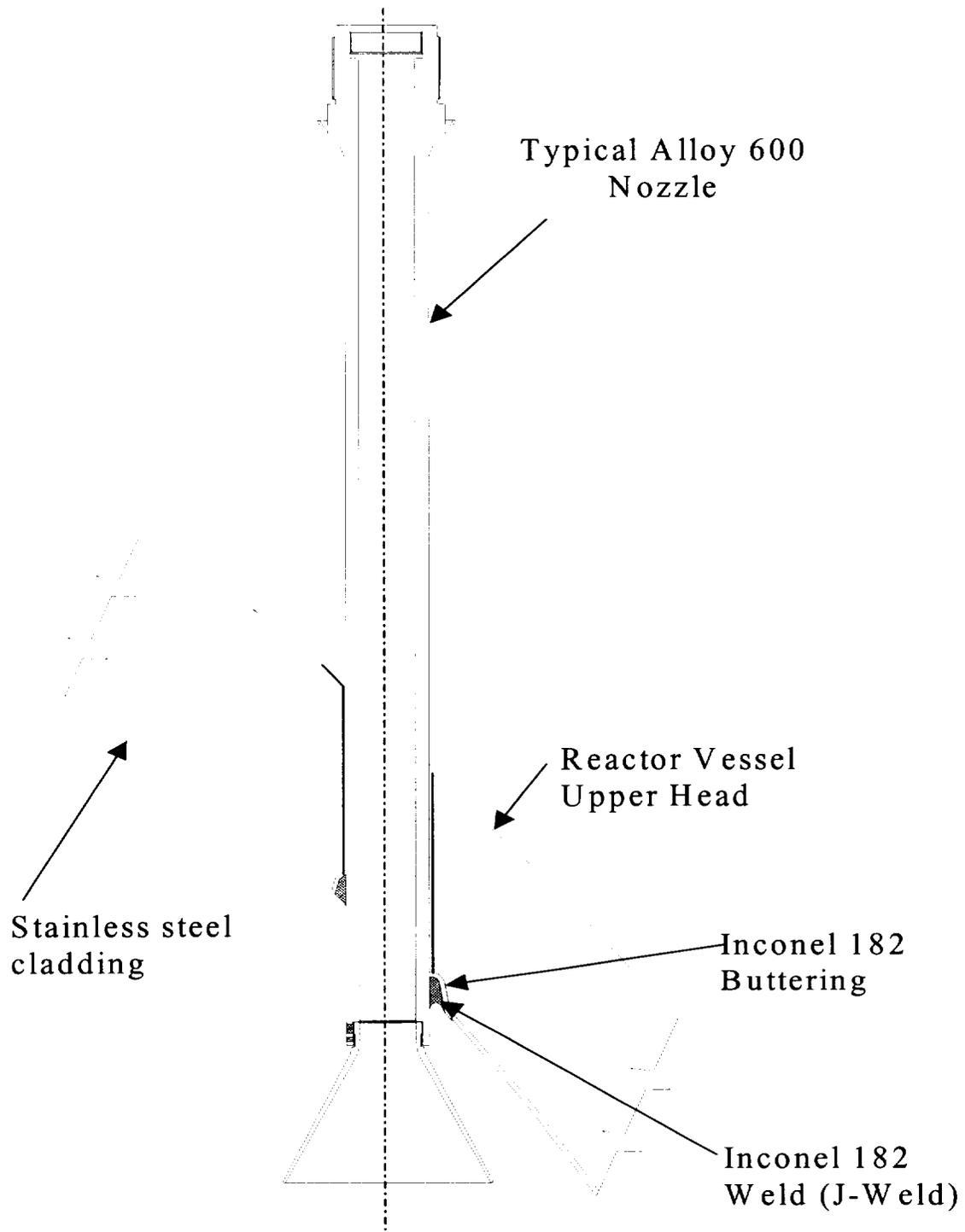
V. CONCLUSION

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

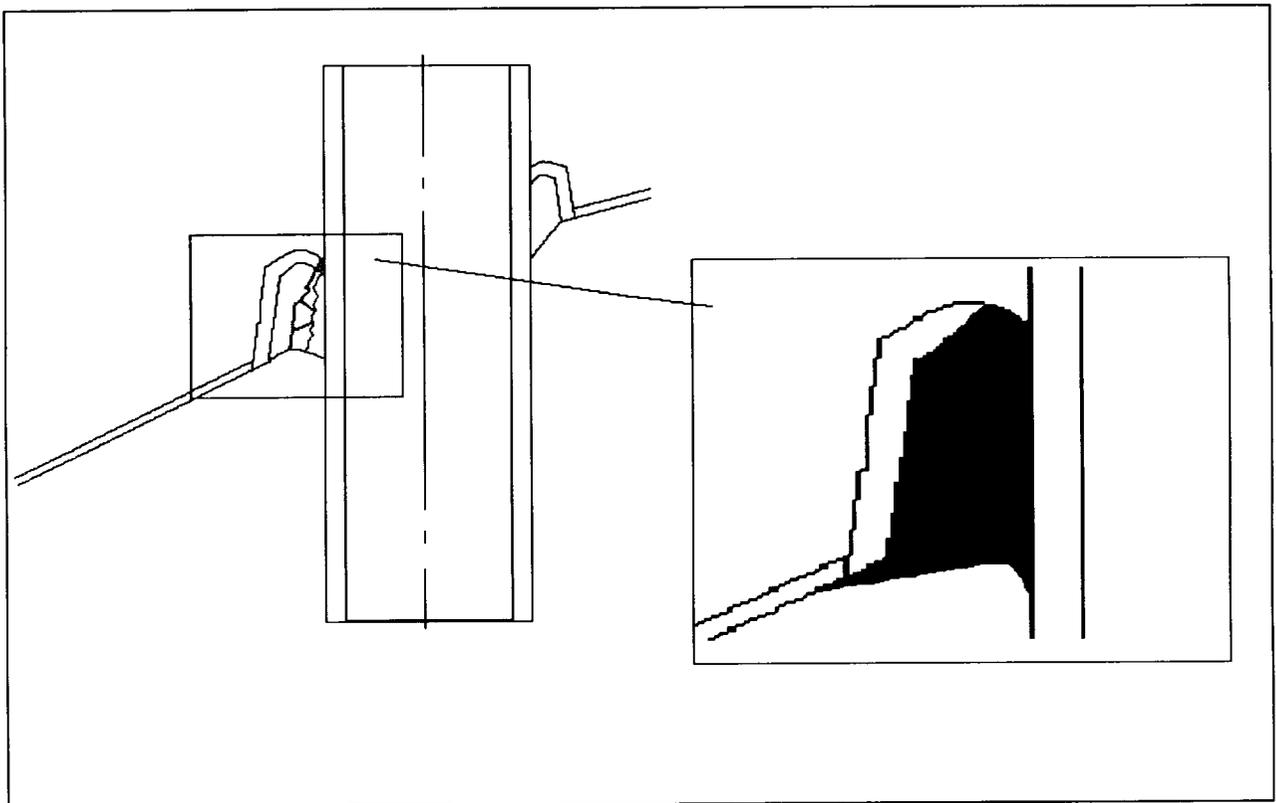
- (i) The proposed alternatives would provide an acceptable level of quality and safety, or
- (ii) Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

Entergy believes that compliance with the repair rules as stated in Reference 1 and as described in Section II of this request would result in unwarranted radiological exposure. The proposed alternative would provide an acceptable level of quality and safety. The proposed alternative would also result in a reduction of radiological exposure to personnel. Therefore, we request that the proposed alternative be authorized pursuant to 10CFR50.55a(a)(3)(i).



Typical RPV Head Penetration Nozzle

FIGURE 1



Example Repair of an RPV Head Penetration Nozzle J-Weld

FIGURE 2

REQUEST NO. PWR-R&R-001

ATTACHMENT 1

**DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE
MACHINE GTAW TEMPER BEAD TECHNIQUE**

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. Repair/replacement activities on nonferritic base materials where the repair cavity is within 1/8-inch of a ferritic base material may also be performed.
- (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 temperature of the area to be welded and a band around the area of at least 1½ times the component thickness (or 5 inches, whichever is less) will be at least 50°F.
- (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) The area prepared for welding shall be suitably prepared for welding in accordance with a written procedure.

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

- (d) The maximum interpass temperature for the first three layers or as required to achieve the 1/8-inch butter thickness in the test assembly will be 150°F. For the balance of the welding, the maximum interpass temperature shall be 350°F.
- (e) 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.
- (f) 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 (h) below, but shall be in the base metal.
- (g) Charpy V-notch tests of the ferritic weld metal of the procedure qualification shall meet the requirements as determined in subparagraph (f) above.
- (h) 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 (f) above. Number, location, and orientation of test specimens will be as follows:
 - 1. The 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. 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.

- (i) 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:

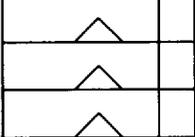
- (a) The weld metal shall be deposited by the automatic or machine GTAW process using cold wire feed.
- (b) Dissimilar metal welds shall be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints.
- (c) The area to be welded will be buttered with a deposit of at least three layers to achieve at least 1/8-inch butter thickness as shown in Figure 2, steps 1 through 3, with the heat input for each layer controlled to within $\pm 10\%$ 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 the ferritic base material to ensure that the HAZ is tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer (or as required to achieve the 1/8-inch butter thickness) in the procedure qualification.
- (d) The maximum interpass temperature field applications will be 350°F 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.

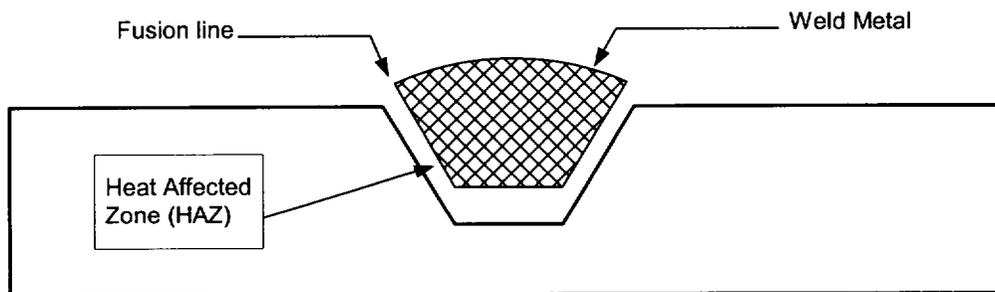
4.0 EXAMINATION:

- (a) Prior to welding, a surface examination will be performed on the area to be welded.
- (b) Repair welds in RPV penetration nozzle J-welds shall be examined as follows:
 - Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. After the completed repair weld has been at ambient temperature for at least 48 hours, repair welds including the preheat band (1.5 times the component thickness or 5 inches, whichever is less) around the repair weld shall be examined by the liquid penetrant method. The liquid penetrant examinations will be performed in accordance with ASME Section III, NB-5000. Acceptance criteria shall be in accordance with NB-5350.
- (c) NDE personnel performing liquid penetrant examination will be qualified and certified in accordance with NB-5500.

5.0 DOCUMENTATION

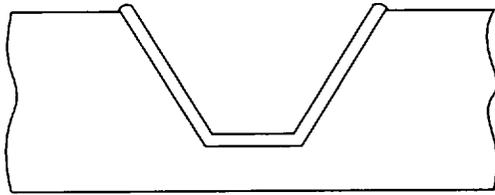
Use of Request No. PWR-R&R-001, Rev. 0 shall be documented on NIS-2. Alternatively, repairs may be documented on Form NIS-2A as described in Code Case N-532 if prior approval is obtained from the NRC.

Discard		
Transverse Side Bend		
Reduced Section Tensile		
Transverse Side Bend		
		HAZ Charpy V-Notch
Transverse Side Bend		
Reduced Section Tensile		
Transverse Side Bend		
Discard		

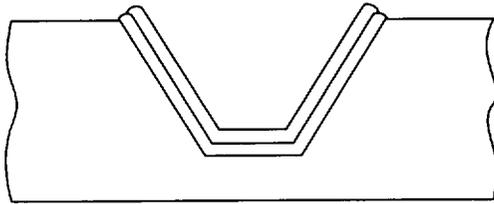


GENERAL NOTE: Base Metal Charpy impact specimens are not shown.

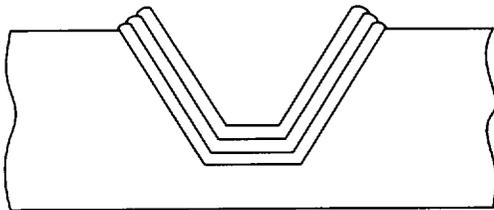
Figure 1 - QUALIFICATION TEST PLATE



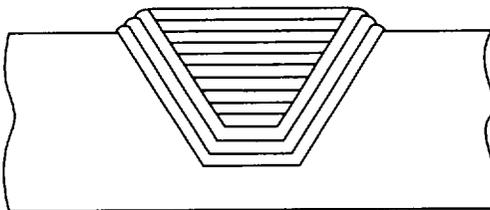
Step 1: Deposit layer one with first layer weld parameters used in qualification.



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: For dissimilar-metal welding, only the ferritic base metal is required to be welded using Steps 1 through 3 of the temper bead welding technique.

Figure 2 - AUTOMATIC OR MACHINE GTAW TEMPER BEAD WELDING